UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Distr.
LIMITED
UNIDO/IS.415
25 November 1983
ENGLISH

INFORMATICS FOR INDUSTRIAL DEVELOPMENT*

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*This is an advance edition of a UNIDO publication to appear in the Development and Transfer of Technology series. This document has been reproduced without formal editing.

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Abbreviations and Explanations

AC	adaptive control
bits	binary digits
CIM	computer integrated manufacture
CMC	Computer Maintenance Corporation Ltd. (India)
CNC	computer numerical control
CP/M	control program for microcomputers
CPU	central processing unit
DNC	direct numerical control
EFT	electronic funds transfer
EPROM	erasable programmable read-only memory
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization of the United Nations
GNP	gross national product
IBI	Intergovernmental Bureau for Informatics
IC	integrated circuits
ILO	International Labour Organisation
ITU	International Telecommunications Union
JIRA	Japanese Industrial Robot Association
Laser	light amplification by stimulated emission of radiation
Leds	light emitting diodes
LSI	large scale integration
MHz	megahertz
MIS	management information systems
NC	numerically controlled
NIA	National Informatics Authority
OECD	Organisation for Economic Co-operation and Development
RAM	random access memory
R and D	research and development
ROM	read-only memory
SPIN	strategies and policies for informatics
STI	scientific and technical information
TCDC	technical co-operation among developing countries
TV	television
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
Unix	a multiuser time-sharing system

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INDUSTRIAL DEVELOPMENT

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1. INTRODUCTION: THE SIGNIFICANCE OF INFORMATICS

1.1 *What is Informatics?*

Over the last quarter of a century new powerful and integrative technologies, based on micro-electronics, have revolutionized the handling of information, and these technologies are still in process of rapid development. We are here concerned specifically with their impact on industry, with special reference to industrial development in the Third World.

Let us set this in perspective. In the first phase of the development of the new information handling technologies, starting in the late 1940's, computers were used, almost exclusively, for scientific calculation. The impact was felt in the natural sciences, where new advances were made possible by the then, relatively, hugh increase in computing power that became for the first time available. A decade later, and continuing to the present, applications of computers began to be made as integral components of organizational systems for information and control purposes in the pursuit of productivity and economic growth. In the early days only the largest organizations could afford to operate a computer. More recently dramatic decreases both in unit cost and in actual size of components coupled with increased flexibility in handling have brought computing power to even very small scale enterprises.

The general trend does not stop there. In the industrialized countries the impact of computerization, or *informatization* as it is also being called, is now felt not just within organizations but by society itself. The systems supporting modern society are

increasingly computer-based and this is affecting the ways in which society is evolving. It is being said that the final phase of informatization is now just commencing, in which the impact will be on the individual for whom the information technologies are creating new potentialities for self-realization.

The informatization of industry may therefore be regarded as but one aspect of a broader socio-economic development. It is convenient to use the term *informatics* to refer to this whole phenomenon that is largely based on the information handling technologies.

Informatics may thus be defined as the field of investigation that takes as its subject matter the variety of ways in which information flows, and the manner in which information is processed, utilized, affects productivity and efficiency, is used for monitoring and control purposes, and finally influences socio-economic development and society itself. The term also connotes the analysis and formulation of national and international strategies and policies for informatization.

Thus the field of informatics is trans-disciplinary and relates to established disciplines of computer science, management science, sociology, economics and political science, engineering and other technological disciplines. In this monograph the information handling technologies on which informatics is based will be referred to as *infotechnology*.

As in the case of other technological frontiers, infotechnology has a massive dual potential both for destruction and for peaceful uses. Other technologies have extended man's muscular power, and

manipulative abilities. The deep significance of the integrated infotechnology of computers, communications and control is that it extends his nervous system and his brain. Only man's will and creative imagination can restrict the pervasiveness of the applications in the support of economic, social and personal development.

1.2 *The Importance of Infotechnology for Industrial Development*

Information is the life-blood of the modern industrialized state. Micro-electronic devices for receiving, storing and processing information, and for control systems, together with telecommunications providing world-wide transmission capabilities, have resulted in radically new ways of handling information in all spheres of industrial and commercial activities. This has lead to increased productivity and efficiency, lower costs, and changes in employment structures.

Infotechnology impinges on industrial development in two ways: as a sector of industry per se and as a feature of industrial technologies in any sector of industry.

As a sector of industry, the manufacture of micro-electronic equipment and components of all kinds, together with the production of software, now constitutes, after energy and transport, one of the three key world industrial sectors, and opportunities for the participation of developing countries in this sector require to be studied in depth.

Infotechnology as a feature of other industrial sectors, in the control of industrial processes, in innovative uses of micro-

processors incorporated in new products, and in information handling for decision support, is likely in the shorter term to have the more significant impact on industrial development, and has the potential to become an effective vehicle for closing the North-South gap.

1.3 *Informatics and the Third World*

To appreciate the connection between informatics and industrial development at the most general level, it is useful to look back at the first industrial revolution in the North, which two-thirds of the world's population is now striving to repeat in the process of transforming their own traditional societies into modern ones. Following on the first industrial revolution, economic developments in the North have been accompanied by a structural shift in employment from the primary and secondary production sectors to the tertiary or services sector. There has grown a requirement for more and more specialization and professionalism in the services sector, which has expanded accordingly. Now, information, and the means and techniques of acquiring information and control, are what this sector deals in. Information is itself a "commodity" that provides the basis for the livelihood of an ever increasing proportion of the work-force.

Perhaps the most significant contrast that can be drawn between the industrialized North and the developing South is that between information-rich and information-poor communities. Information as a commodity is lacking in the South.

The proposition can therefore be advanced that, although in the course of industrial development in the Third World, the services

sector will in any case expand as an automatic accompaniment, nevertheless an accelerated rate of development could be achieved by a primary concentration on the services, or information sector; that is to say, by giving priority to the informatization of this sector.

It can be argued that the services sector is critically important to development and that the infotechnology applications that underpin activities in this sector are appropriate for speeding up socio-economic development in the Third World.

Narasimhan[1/] discusses the importance of the services sector to developing countries with special reference to India as an illustration. The industrial base in India is quite comprehensive, having as a constituent part every component of the primary and secondary production sectors. Why is India, then, not regarded as an industrially advanced country? The answer is that industrialization has not been accompanied by a structural shift of the labour force from the traditional occupational categories: industrialization has been grafted on to a society that continues to function to a large extent in its traditional mode. As a result many occupational roles in the service sector that could be contributing to the efficiency and productivity of the primary and secondary production sectors have not been created.

This is one basic aspect of the low level of information consciousness that is common to all socio-economic activities. However it is measured (in terms of newspaper circulations, books, telephones, radio, etc.), information consciousness is less by several orders of magnitude in developing countries compared to the

industrialized North.

In India, as in many other developing countries, the two major stumbling blocks to achieving rapid socio-economic development are massive illiteracy and an extremely poorly developed communications infrastructure to support information transactions among people living in geographically dispersed small communities. Provision of education, health care and community services pose problems that only radically innovative unconventional approaches can solve. Informatics has a vital role to play in extending the scope and improving the standards of functionally available systems in a society.

1.4 *Scope of the Monograph*

In this monograph an examination is made of the opportunities and threats, constraints and the necessary national infrastructure relating to the informatization of industry in developing countries.

In the course of this examination a number of complex issues are confronted. For the Third World, industrial development is a priority. Studies are revealing that informatics will profoundly affect the productive infrastructure and the international division of labour. Policy options for industrialization are narrowed. A re-conceptualization of development strategies is called for and developing countries must not merely reproduce what the industrialized North has done but base their actions on an assessment of long-term comparative advantages.

We begin with a brief survey of infotechnology and its overall impacts on industry and society, including the hardware and

software industries that are based on it, the development of new products and processes, and information systems.

The potential economic effects on productivity and employment are of major concern and this issue is next taken up.

We then look at informatics development in the Third World. Informatics as a major concept on which action can be based to promote self-reliance is proposed. A conceptual framework for national informatics development is presented. Informatics development is a dimension of technological development which in turn is an integral part of national economic development. National policies and strategies are enumerated.

Since the informatic industry now ranks in size with energy and transportation, it must itself be a subject of study as a sector of industry. How they can participate in this industry is therefore an issue of major interest to policy makers in developing countries. The policy options, preconditions and constraints relating to an indigenization strategy are examined in some detail.

We then go on to consider the necessary infrastructures for informatization in other industrial sectors. The necessary infrastructures to support organic and self-sustaining growth are examined, with particular reference to education and training, industrial information structures, telecommunications, and R & D.

International actions under many different heads will be essential for the promotion of informatics development in the Third World. We therefore discuss the role of international bodies in the promotion of: national policies and strategies; awareness, education and training; information infrastructures; communications infrastructures; hardware and software industries; new products and processes; applications.

Finally, a suggested checklist of actions for an individual country is given for use in the formulation of an operational strategy.

1.5 *Summary*

What emerges may be briefly summarized as follows: Informatics has immense potential but there are many constraints that militate against the setting up of indigenous informatics industries in the developing countries, and these countries have at present only a tiny share in this vital sector. The development of this sector however is seen to be crucial for achieving technological self-reliance of the developing countries.

Severe structural and cultural constraints also hinder the effective implementation of even the simplest applications. Developing countries are heterogeneous and the circumstances of each will need to be separately considered. Specific pilot projects and case studies and the diffusion of information on them are urgently required.

The problems are particularly acute because infotechnology is the prime example of a systems technology which only works

effectively when many interacting components, people and hardware, are brought into harmonious relationship.

Mechanistic "solutions" to poorly understood problems must be avoided. Education and training have the highest priority and an effective informatics policy will be people oriented: one that seeks to improve existing skills rather than replace them.

The question remains whether fundamentally new insights are still required for the promotion of self reliance. The concept of an organizing principle which Dedijer[2/] calls social intelligence must surely be pointing in the right direction.

NOTES AND REFERENCES FOR CHAPTER 1

1. Narasimhan, R. (1982), *The Socio-Economic Significance of Information Technology for Developing Countries*, in Foster, F.G. (Ed.), *Informatics and Industrial Development*. Proceedings of the International Conference on Policies for Information Processing for Developing Countries, 9-13 March, 1981, Trinity College Dublin, Ireland. Tycooly International Publishing Limited, Dublin.

   Note: Future references to these proceedings will be given as Dublin Conference.

2. Dedijer, S., Dublin Conference.

2. THE TECHNOLOGY AND ITS IMPACTS

2.1 *The Technology*

Infotechnology as the technical support for human thinking and communication has been evolving over thousands of years. Although the developments have speeded up dramatically over the last few decades, nevertheless it is important to be aware that the technology is still in a phase of very rapid change and development.

Information

The actual matter of thinking and communication is *information*. Throughout the ages, the *representation* of information has been a basic human requirement and various means have been used along with devices for storing, transmitting and processing information and interfacing with users. Early examples of the technology are Stonehenge, the Abacus, the printing press, Jacquard's loom, the mechanical calculating machines of Pascal and Leibniz[1/]. The twentieth century then saw the development of the electronic computer.

The systems used to represent information in all these developments can be classified as either *analogue* or *digital*. In an analogue device, information is stored and transmitted in a form which has a direct correspondence with the form of the original information, but in a different medium. The thermometer, slide-rule and the traditional gramophone record are examples.

In a digital device, the information is coded and the coded form bears no relation to the original. Any coding system can be

reduced to a sequence of just two symbols which can then be made to stand for anything and its opposite, such as "yes' and "no", the digits "1" and "0", "on" and "off", etc. These basic units are referred to as "bits" (standing for binary digits). Examples of digital devices are the Morse Code, the pocket calculator and the Compact Disc for the digital recording of music.

Logical Processing

The system of codding using bits is known as the *binary system*. The Irish logician, George Boole, had shown already in the nineteenth century how to develop a symbolic logic using the binary system such that logical reasoning can be reduced to a calculus. In 1937 electrical switching circuits were first developed which embodied Boole's principles. This was one of the significant advances in infotechnology since it enabled the logical processing of information to be automated. The switching elements in the circuits are called *logic gates*. Logical functions embodied in the circuitry may be very complex requiring thousands of such logic gates.

Integrated Circuits (IC)

Initially switching circuits were constructed out of electro-mechanical components. Then in the 1940's thermionic valves were incorporated in logic gates. This led to the development of the first electronic computers.

These computers were hugh and costly and developments were slow until the first solid-state electronic switching device, the transistor, made from materials known as semiconductors, was developed at the beginning of the 1950's. This invention led quickly to the development of integrated circuits (IC) and the microprocessor.

The transistor was a discrete device but a fabrication technology was developed whereby it became possible to combine a number of components onto a single integrated circuit etched on a wafer of semiconductor material, silicon, as substrate using techniques of photolithography. By 1963 up to eight separate components were being integrated on a single "chip" of silicon. By 1970 the figure had risen to 2,000 and now manufacturers are producing integrated circuits with half a million components on a chip less than half a centimetre square.

Large Scale Integration (LSI)

The fabrication of integrated circuits is known as Large Scale Integration (LSI) and is the culmination of the drive towards miniaturisation. The goal of LSI has been cost reduction of the devices produced through mass production of many circuits at a time and the reduction of the elements and interconnections to the smallest possible size. The technology is generally referred to as semiconductor technology. The fabrication process is complex and demands extremely expensive and sophisticated equipment, operating under carefully controlled conditions in an absolutely dust-free environment. To compete in the market, manufacture has to be in large quantities and initial costs spread over a wide market.

The initial stages of the manufacturing process, namely the design and layout of the circuit are still highly-skilled, manual operations. Several man-years may be needed for a complex circuit.

Likewise the end-stage, the final packaging, has until recently been labour-intensive and has led to off-shore operations where labour is

cheaper. Improved packaging technology is however highly automated, resulting in a recent trend towards repatriation.

The Principle of the Computer

The revolutionary concept of the programmable universal computer goes back to the nineteenth century English inventor and mathematician, Charles Babbage, but its full realisation had to wait for the invention of electronic switching circuitry and the vital concept of the *stored program* due to Van Neumann in 1946.

The stored program concept provided an evolutionary jump in the development of the computer endowing it with its modern flexibility and capability of performing tasks that are associated with "intelligence". The computer is a general device for automatically processing information. That it only performs calculations is a misconception: numbers are themselves coded information and calculations are only one particular kind of information processing. The invention of storing instructions in the computer in the same way as other data enabled a computer to process its own instructions and modify them just as it processes the data which are the subject of the instructions. Instructions and data are put on the same footing as *bits* of information. The consequences have been far-reaching in a wide variety of ways in the further development of the technology.

The basic elements in the design of a computer are: a *program* of instructions specifying the operations to be carried out; *input* devices such as keyboards, magnetic tape readers, light pens, sensors, by means of which the program together with the other information on which it is to work can be fed into the machine;

memory devices to receive and store the information; a *central processing unit* (CPU) to carry out the instructions; and *output* devices such as printers, TV screens, actuators, to pass on the results to where they are required.

Memory Devices

Devices for storing information are classified as primary or secondary storage. Primary memory devices are LSI devices, i.e. memory chips, which are regarded as an integral part of the computer. Secondary devices are external components consisting of magnetic discs, of either the rigid or "floppy" types, and magnetic tapes.

Primary memory has to date been more limited in capacity than secondary but their advantage is that the time required to access information is faster, being a fraction of a millionth of a second. Primary memory is thus used for holding information that requires fast access or frequent access, and in particular for holding instructions currently being executed.

Memory chips may be read-only memory (ROM) containing information that may not be altered and cannot be erased. Random access memory (RAM) contains information that may be over-written. Other types of devices are programmable read-only memory (PROM) which can be once only programmed by the user, and erasable programmable read-only memory (EPROM) which can be rewritten and modified by the user at will.

RAM chips are commercially available with a capacity of up to 64,000 bits of information but chips with capacity of 128,000 are now emerging.

Secondary memory systems provide virtually unlimited capacity but with slower access times. While magnetic based systems are currently in use. other systems are being developed which will provide storage which will be several orders of magnitude more compact, faster and cheaper. These include magnetic bubble memories with no moving parts and laser-based optical systems. Such developments will provide even brief-case computers with virtually unlimited memory and increase enormously their capabilities.

Microprocessor, Microcomputer and Mainframe Computer

A microprocessor is a single LSI chip, like a memory chip, but having the function of a CPU. Limitations of chip size mean that microprocessors to date have been constrained to having a single structure and a shorter word length than is customary in CPU's that use the older discrete circuitry.

A microcomputer is a complete system processing, in addition to CPU, memory and input/output units.

Microprocessors and microcomputers are rated by the word-lengths they employ. The 8-bit word length is common, but 16 bits are now available and 32 bits is projected within the next few years. An 8-bit microcomputer can process only 2^8 (= 256) bits of information in one instruction cycle. A 16-bit microcomputer is much more powerful in being able to handle 2^{16} (= 65,536) bits in the same time. On the other hand it requires correspondingly a much greater number of components per chip.

The mainframe computer has typically a work length of 32 bits. It still depends on discrete circuity and is still necessary for

applications requiring large-scale information processing or calculations. LSI technology is increasingly being used where possible to enhance capacity and reduce energy requirements. The technological race to make faster mainframes is still on and it is reckoned that the demand for big computers will keep pace with that for the minis and micros for the rest of this decade.

Communications

Revolutionary developments in communications technologies have resulted in telecommunications services which now rely on equipment which simply did not exist thirty years ago: satellites, microwave, microprocessors, optical fibres. It was the introduction into telecommunications of the digital mode of transmission of information that has brought about the convergence in infotechnology, between all the information handling technologies of communications, computers and control, facilitating the development of an integrated informatic infrastructure across a wide range of industrial sectors.

Communications technologies are of three basic types: transmission, switching and terminal technologies. Transmission is concerned with the means of transmitting the signals over distance; switching is concerned with the mechanisms of Exchanges for connecting users; and terminal technologies are concerned with the user devices for initiating and receiving signals.

Technological advances in transmission have increased the options for transmission media while increaseing the efficiency of each medium. Copper coaxial cable is the traditional medium of transmission. Improvements in cable technology have increased transmission quality and voice circuit capacity and transmission

costs per voice circuit mile have steadily fallen. In the 1940's microwave radio transmission was developed. This increased the options since coaxial cable cannot be laid in uneven terrain. On the other hand, microwave must travel on a line-of-sight path and relay towers, spaced at around 40 kilometers, are needed to boost the signals, and these also require maintenance.

Optical fibre cable is a third recently developed transmission medium, now still in its initial phases. The cable consists of glass thread about the thickness of a human hair carrying concentrated beams of light. Two methods are used to emit signals along optical fibres: light emitting diodes (Leds) and light amplification by stimulated emission of radiation (Lasers). Leds are generally used for lower transmission volumes and Lasers are required for high-speed transmission. Basic advantages over copper wire are that the material of fibre, silica, is cheaper and more available than copper, and the fibres have a much greater transmission capacity. They are more resistant to corrosion and require fewer signal boosters on long routes. They are also immune to electrical interference so that they are much more reliable in environments where high currents may be passing, and they provide higher security against unwarranted tapping.

Rapid progress in optical fibre technology, associated with steep declines in costs, are expected to result in very high expansion in volume of usage and also range of fibre optic applications, for long haul transmission and for distributing a broad range of communications signals, in addition to the traditional telephone, to the home: data, facsimile, voice and image.

Satellite communications are a special application of microwave systems. The microwave signal is reflected off a satellite stationed

at an elevation of 22,300 miles in geosynchronous orbit. Their development has further dramatically increased transmission capabilities since they resolve the constraints of the construction of terrestial networks of cable or microwave, and they are virtually cost insensitive to distance. Many countries are now operating communications satellites with communications links to associated ground stations. INTELSAT[2/] provides service designed for global use. Its first satellite ("Early Bird") was launched in 1965. It weighed 38 kilos, supported a bandwidth of 50 MHz and 240 two-way telephone circuits; INTELSAT V (1980) weighs 1,000 kilos, supports a bandwidth of 2,300 MHz and 12,500 two-way telephone circuits. Costs have correspondingly declined.

They have a hugh potential for increasing global signal carrying capacity to provide global TV transmission, person-to-person communications, electronic mail and all the other broad-band services. The main drawbacks at present are the high cost of construction and launching but the launching costs will decline substantially with the entry into operation of such launchers as the Space Shuttle and Ariane. Currently satellite communications account for only a small proportion of global communications; although their use will be greatly extended, they are not expected to be a complete substitute for terrestial networks on account of constraints on "parking spaces" for geostationary orbits and availability of radio frequencies.

Switching technology developed rapidly in the 1960's with the application of computer control to replace wired logic circuits. These models were still partly electromechanical for the alignment

of the circuits. Fully electronic switching, operating in a digital rather than analogue mode, became operational in 1970. The shift to digital mode has significant advantages, arising out of its compatibility with integrated circuits and microporcessors, and complementing the developments in transmission media. Representation of all information, whether originally voice, video or data, becomes identically a series of bits, so that the way it is switched or transmitted is independent of the original format. Merging of speech and data along the same cable, utilizing natural breaks within speech, became possible as did packet switching to route traffic optimally through a network, resulting in cheaper and faster service. Digital mode also greatly improves quality of transmission.

The technology of terminal equipment is now in a stage of rapid development, especially in regard to increasing the speed, quality and reliability of equipment for image and text communications. This has led both to substantial improvements in the traditional business and private communications equipment and also to the development of completely new types of terminal equipment. These include the following.

Data Terminals for direct communications between computers and between terminals in one locality and computers elsewhere have developed from the basic teleprinter of the 1960's to meet a range of different requirements: high-speed terminals, light-weight portable terminals for field communications, text editing/video display terminals with graphic capabilities for scientific applications, etc.

Facsimile Machines have been available since the 1930's for reproduction of an image transmission but technological advances

have reduced the time required to transmit an A4 page to less than 30 seconds.

Communicating Word Processors connect machines capable of storing, retrieving and editing text.

Teletex refers to work-stations (intelligent terminals) capable of exchanging letters. It is an updated version of the traditional Telex service.

Telewriting refers to a graphic tablet, light pen, keyboard and screen[3/] which enable hand-writing to be transmitted and reproduced. Applications include conferences, teaching, etc.

Videotex systems provide consumer access to and retrieval of information in computerised data bases. The information available is of a business or social nature, identical to that normally distributed through newspapers, magazines and books but the system provides selectivity in retrieval. Adapted television receivers display the information. Interactive functions may be included such as library services, teleshopping, computer aided learning, etc.[4/] Videotex was originally developed in the U.K. and rapidly attracted worldwide attention.

Teleconferencing enables people who are geographically remote to hold conversations, possibly also viewing each other live on TV screens[5/]. This could be a significant development for business communications, particularly between branches of large scale

geographically decentralised organisations.

Software

The physical components of computers and other equipment are often referred to as *hardware*. *Software* is a generic term for the sets of programs which control the functioning of any complex information system.

A computer has a set of operational functions engineered into its logical design. A program is a planned procedure for solving a problem or carrying out a task and consists of a list of instructions which, when read into the computer and stored, determine precisely the sequence of functions performed and on what data they are performed. Instructions to the computer are themselves just sequences of bits and may be processed and modified by the computer's logical functions in precisely the same way as other data. As mentioned above, this stored program concept has opened the way to many developments including what is referred to as "artificial intelligence".

Programs operate at different levels. At the highest level are the *applications programs* which carry out a particular task such as a payroll, accounting, etc. The instructions of such a program will be coded according to some set of conventions which are helpful to the individual who is constructing the program. These conventions constitute the "language" of the program. Various languages have been developed such as BASIC, COBOL and PASCAL which more or less resemble human language. At the next level these coded instructions will then first be operated upon by another program and translated into the language which the computer understands. Such programs

which have the task of operating upon other programs in this way are called *compiler* or *assembly* programs, and are generally supplied with the computer.

At the lowest level then come the programs of the *operating system*, supplied by the manufacturer (e.g. Unix or, in the case of many microcomputers, CP/M). The operating system acts as general manager and ensures that all instructions and data get to the right place at the right time and in the correct order.

Much effort has been and still is being devoted to the development of computer languages in the pursuit of greater efficiency both in the writing of programs and in their execution. Programming still remains skill-intensive and defies mass production methods. Computer architectures and languages are interdependent, developments in one area stimulating developments in the other. Thus since most computers are sequential so are most languages but much effort is now going into the development of so-called declarative languages which provide for parallel rather than sequential processing and have much greater power than conventional languages.

Special purpose software is now required not just in the conventional general purpose computer but is an integral part of an increasing number of products, telecommunications switching gear, satellites, space vehicles, etc.

2.2 *The Industry*

The informatic industry includes: hardware; software; electronic components; and telecommunications equipment.

Hardware

The hardware industry is characterised by very rapid technological development and requires high R & D expenditures. A number of phases in the production process are being automated on an increasing scale: design (computer adied design); assembly (robot-use); testing (computerised)[6].

High sales volumes must be achieved to finance the high levels of investment necessary. In practice this means that hardware products must be competitive in world market terms. Manufacturers of core hardware, and to a lesser extent, manufacturers of peripheral hardware, are concentrated in a small number of highly industrialised countries. Recent developments in microelectronics technology, culminating in the microprocessor, gave rise to the semiconductor industry. This gave scope to enterprises to enter the production of hardware at a number of different levels. This is likely to lead to a greater spread among countries of hardware producers. In addition the boundaries between the hardware sector proper and other sectors where microprocessors are incorporated into products and capital equipment will tend to become blurred[7].

Software

Partly because of rapid developments in hardware and also because the creation of software is highly labour-intensive, there is a lack of software worldwide. The development of 'firmware' - fixed programs built into the computer at time of manufacture - has not, as was hoped for, overcome this problem. Neither has the encouragement of the use of high level languages. The lack of software compatibility among different types of hardware accentuates the shortage of software.

There is a wide spread among countries in relation to the creation of software. The basic prerequisite for setting up a software industry is the availability of appropriately skilled manpower. A high level of capital investment in plant and machinery is not required. It is likely that, in the future, there will be less emphasis on general-purpose software and more attention given to application-specialised software which would focus on particular problems to be solved[8]. This will provide an impetus to the further spread of the software industry[9] among countries.

Electronic Components

The electronics components industry as a post-war development has experienced spectacular growth [10]. Now dominated by the semiconductor industry it originated in the US. The US industry is still both the largest and the most developed even though Britain, France, Germany and Japan quickly developed their own semiconductor industries in the wake of the US. Licensing arrangements are often made because large customers generally need a second source of supply. This contributes to a reasonable flow of information within the industry. The original character of the industry, with its diversity and many new ventures, is being replaced by a consolidated mature industry of a few large advanced firms, surrounded by some satellite ancillary suppliers.

Telecommunications Equipment

Advances in technology have stimulated rapid developments and change in the telecommunications equipment industry.

This industry is concerned with three basic types of equipment: terminal equipment (e.g. a telephone set); transmission equipment (e.g. coaxial cable, microwave radio or communications satellites); and switching equipment to link the terminals as required. On a rough estimate, telecommunications equipment accounts for approximately 30 per cent of output of electronics-based goods. The OECD countries account for the bulk of world production of telecommunications equipment. A small number of firms, most of which are multinational in their operation, accounts for the vast majority of world sales. The largest geographical markets for this equipment are North America and the industrialised countries of Europe. The geographical concentration of world production and sales reflects the international distribution of telecommunications infrastructure.

For most of the post-war period, the industrial structure of the telecommunications equipment sector has been relatively static, with a near monopsony (a situation in which a single buyer dominates the market) on the buyer's side of the market being balanced by a stable supply oligopoly. More recently, this structure has begun to change under the impact of advances in technology[11/].

2.3 *Microprocessors in Products*

There is virtually no field in which semiconductor technology is not having an impact, in the home, office, factory, schools, hospitals, transport. Except in a number of specialised cases (e.g. Defence: see Section 2.10) applications do not now rely heavily on further technological developments for speed, size or reliability. The rate of development is not, by and large, constrained by the currently available technology but by economic and social factors and by the

imagination of the potential innovators.

In looking at the applications of the technology in end-products, it is useful to distinguish between improvements in existing products and new products.

In existing products, semiconductor technology is used to replace the older electrical circuitry or electro-mechanical technology, resulting in more flexible, "smarter" products with enhanced performance but having essentially the same functions as the older products and satisfying the same market. But the advent of the semiconductor and associated technologies also create the possibility of developing entirely new end-products, with new capabilities and for a new market.

Existing Products

The clock and watch industry is a good illustration of an industry in which the rate of penetration of the new technology was extremely rapid to the extent that most of the end-products now incorporate the new technology.

Another example is the automobile industry where a great variety of microelectronic devices are being incorporated into vehicles for driver support and for control and monitoring purposes.

Other examples are domestic appliances such as washing machines; office appliances such as photocopiers and word processors; industrial instrumentation where electronic gauges, meters and displays have widely replaced their mechanical or electro-mechanical equivalents; and weapons systems such as ballistic missiles.

New Products

The pocket calculator is often cited as the typical example of a new product made possible by semiconductor technology[12]. Though mechanical, electro-mechanical and electronic desk calculators have existed for many years, the small size and flexibility and ease of use of the pocket calculator opens up a new market and an entirely new range of applications.

An example of a new product which, unlike the pocket calculator, has no predecessor possessing anything like similar functions, is the plastic bank card incorporating a microcomputer[13]. As pointed out below in Section 2.7, the implications for the banking industry of the development of this product are enormous.

Other examples of new products are video games; home computers; "intelligent" paramedical products and devices used in health care delivery and to support the physically handicapped; and communications satellites.

Clearly however innumerable useful new products and processes are still waiting to be discovered. The pace of implementation is slow. In addition to the economic, social and infrastructural factors involved, there is the basic problem of two-way communications flow between the potential end users with their needs and the manufacturers and component makers with their technology. Cremin gives a thoughtful discussion of this issue in the context of the banking industry[14].

The feasible products incorporating the new technology are virtually infinite and defy enumeration. They can be envisaged in all situations[15]:

- where a sequence of repetitive actions has to be carried out;
- where information has to be stored and retrieved;
- where monitoring, comparison or reaction to situations is required;
- where speed of response is important;
- where the environment is hostile or uncomfortable to human operators;
- where sensors can provide feed-back information and actuators can be triggered in response;
- where reliability, cheapness and small size are important.

2.4 *Impact on Research and Development*

R & D is the traditional application of computers, which were invented to do the large number-crunching applications of scientific research. Infotechnology now constitutes a critical tool at the leading edge of the expansion of knowledge in every field and impacts R & D in a number of other fundamental aspects in addition to the original application of computation[16]. These include interactive computing in which the researcher can experiment in real time with theoretical formulations, the use of interactive visual terminals in design applications to explore alternatives, the use of graphics terminals, large-scale modelling and simulation applications, and the use of data-bases and computer networks for dissemination of new knowledge.

2.5 *Industrial Automation*

A rapid expansion in the number of applications of computers in

manufacturing industry took palce in the 1960's.

The applications may be divided into on-line and off-line applications. An on-line application is one in which the computer is directly linked to the manufacturing operation. It processes state information to function as either

(i) a control system or
(ii) a monitoring system.

The monitoring function may also be a by-product of the control system. Its purpose is to register and report production data to provide management with current information for decision making.

Off-line applications are those in which the computer operates independently of the manufacturing system and processes pertinent textual information.

For a detailed survey of how manufacturing industry's efficiency and productivity is and can be improved through the use of microelectronics see Owen[17].

Control Systems

Microelectronics based control systems are used in industry for the direct control of manufacturing operations, such as the movement of materials, components and products, control of temperature, pressure and humidity, the shaping, cutting, mixing and moulding of materials, the assembly of components into sub-assemblies and finished products, the control of quality by inspection, testing and analysis.

In each case the state of the manufacturing process variable is translated, by means of an appropriate sensor device into an input signal. This information is processed and transformed into an output signal which may then be processed to determine, for example, a mechanical movement or adjust a temperature electrically by means of an appropriate actuator.

In certain applications the system may be programmed to achieve optimum operational conditions through the simultaneous control of a large number of variables, e.g. in the petroleum and petrochemical industry.

The Process Industries

The earliest applications of control systems were in the process industries, whose plants convert raw materials and energy into products such as chemicals, petroleum, metals, pulp and paper, food, cement, textiles and electric power. Instruments monitor process variables such as flow rate, temperature, pressure, chemical composition and liquid level. A typical plant, such as one for manufacture of ethylene or ammonia, will have several hundred control values and more than a thousand measured variables. Changes are made in the operation of the process on a time scale ranging from a few seconds to a few hours [18].

The Manufacturing Industries

In the manufacturing industries - automobiles, appliances, spare-parts, etc. in contrast to the processing industries, the geometries of their raw materials are manipulated so that discrete parts are assembled to

form products. The methods of measurement and control are basically different from those used in the process industries, and the problems of automation more complex, but there are now in operation in the US, Japan and Europe highly automated plants turning out automobiles, engines, earth movers, oilwell equipment, elevators, electrical products and mechanic tools.

ONe of the most significant early applications of automation in manufacturing was the introduction in the 1950's of numerically-controlled (NC) machine tools. Coded numerical instructions controlled the fixed sequence of machine operations. Later the hard-wired conventional control was replaced by a minicomputer programmed to perform the control functions: Computer Numerical Control of Machines (CNC). Other developments include Adaptive Control (AC) of machine tools in which the computer is used to measure, for example, cutting forces and speeds and to control the axis motion and spindle speed accordingly so as to maintain the optimal metal renewal rate; and Direct Numerical Control (DNC) of machine tools in which a general-purpose computer is connected directly to a number of NC machines[19].

Industrial Robots

The concept of a control system leads on naturally to the notion of a "universal" machine that has the flexibility to perform a variety of tasks. Development of such industrial robots which commenced in the late 1960's has been given a considerable boost by the capacity and flexibility of microprocessors and rapid progress has been achieved which resulted in their practical application in the first half of the 1970's. It is estimated that there were 8,000 robots in

use worldwide in 1978[20/], the commonest applications being in coating, welding, pressing and injection moulding, particularly in the domestic appliances and automobile industries. It is not generally anticipated that their dissemination will be other than gradual although the Japanese Industrial Robot Association, JIRA, established in 1971, expects that they will come into general use in the industrialised countries in the 1980's.

Industrial robots are commonly defined as manipulators which have a high degree of freedom and which perform versatile movement functions. The table shows the classification of industrial robots and their respective definitions as approved by the Technology Standardisations Committee of JIRA in 1974[21/].

The notion of an industrial robot involves an approach to automation which differs from the traditional approach in that in the past the technology has been designed to perform a task in a manner not necessarily similar to the one used by humans.

By contract, a robotic approach to automation follows human performance much more closely, since it reflects a move away from "purpose-built" machines towards "universality"[22/]. Clearly this has its advantages and disadvantages and the economics of robotics must be carefully considered. The availability of highly developed off-the-shelf robots will facilitate the introduction of automation, but they would tend to be more expensive than purpose-built automatic devices when applied to simple, common jobs. On the other hand with a large enough market for robots, the design and development costs can be spread.

Manufacturing Design and Production

These systems are concerned with the off-line processing of textual or diagrammatic information pertinent to manufacturing design and production planning and control. They include:

- Computer Aided Design (CAD);
- Requirements planning;
- Capacity planning;
- Scheduling;
- Purchase control including replacement of raw materials, stock control and purchase order control;
- Production and assembly control including materials control, load control, inventory control, tool control, job control and dispatching.

This type of application is usually the result of applying the computer to a previous manual procedure and permits the optimisation and simulation of plans which would be impossible in the time available using manual means.

Computer Integrated Manufacture

Industrial applications of informatics have inevitably taken place in a piece-meal fashion. Particular problems have been solved but the contribution of the computer has often been less than that forecast. It has become apparent that it is not enough to superimpose computer technology onto traditional manufacturing systems and that a total systems approach would be desirable.

The title Computer Integrated Manufacture (CIM) has been given to

such a total technology that will integrate all aspects of the manufacturing activity from initial design to warehousing, sales and service, all controlled by individual modules of computer software linked together in a hierarchical system. CIM will involve very substantive software development and will be evolved only over a fairly long period of time.

2.6 *Office Automation*

Curnow[23] expects that, in the long term, office automation will be the main growth area for infotechnology and will have a radical impact on the efficiency of information flow within a company. All office procedures can be coordinated and rationalised, and all transactions continuously monitored, by means of the appropriate application of infotechnology. This will result in the so-called 'integrated office'[24]. Some of the components of these developments are already quite advanced in the industrialised countries. They are focused on data processing and word processing applications. Others, such as image processing and audio processing capabilities, are at a relatively early stage of development. Image processing enables complex data to be represented in visual forms. Products such as facsimile machines, display graphics, etc. fall within the scope of image processing. This technology can play an important role in improving office productivity. Audio processing refers to electronic input and output mechanisms in the form of direct speech. Important developments are expected in the longer term in this area of electronic voice recognition[25], which will clearly affect office management in fundamental ways.

Word processors, based on the more traditional data processing technology, consist of video display screens with keyboards, central processing units with internal and external memory and printers[26]. These have the following capabilities: information capture, information storage, information manipulation, information distribution and electronic control of typing and printing. Word processing applications offer massive scope for securing improvements in typing productivity[27]. Interconnections between word processing stations, through telecommunications systems, will stimulate developments in the area of electronic mail. The optimum benefit of word processors will not be realised until full use is made of the potential for interconnections and access to central filing systems, etc. to provide integrated filing, cataloguing and dissemination of information, both within and outside the office, is made available. In this way an effective and direct working tool for managers for the management and communication of information will develop.

There are now in widespread operation general computer-based corporate systems such as financial planning, wages and salaries, pensions systems, that are not related to any particular industry, for which the development of the software has involved very heavy investment of man-years.

2.7 *Electronic Funds Transfer*

The potential impact of infotechnology on the banking industry is great. Currently the industry faces a basic structural problem of uneconomic porducts and disproportionately high staff and premises costs, which provides ample incentive to change from operations

involving the movement of pieces of paper to using electronic transfers and chequeless banking.

The term *electronic funds transfer* (EFT) covers all transactions, using on-line computers to directly debit or credit accounts, between banks or branches or between customers and branches, or at point-of-sale transactions transferring the cost of the purchases from the customer's to the store's account[28]. Perhaps even more significant for the future of banking[29] will be the development of personal plastic cards with imbedded low-cost microcomputer, for use as electronic wallet, permitting value to be passed from card to card without bank intervention. Such cards are envisaged as personal, cheap, portable and powerful payments instruments.

Changes to EFT require reorganisation for which few of the parties involved (state, banks, insurance companies) are yet ready[30]. But the trend [31] is there and fundamental change in the financial structure of banking will occur, from the present type of labour-intensive service industry with high staff and premises costs to a decentralised, self-service, capital-intensive industry with very low premises and staff costs.

2.8 *Decision Support Systems*

In the industrialised countries the use of computer based management information systems (MIS) has become widespread in enterprises to support the function of management.

Management of an organisation occurs at three functional levels: operational, tactical and strategic. The first level refers to the routine day-to-day operations, the second to the control and evaluation of these operations, and the third to long term planning. In the industrialised countries, management information systems have gradually evolved through these three levels over a period of thirty years.

The first two levels contribute to the productivity of the organisation. The third level contributes to its survival and growth: the contrasting concepts are those of *social efficiency*[32] and *social intelligence*[33]. While social efficiency is a product of a good management infrastructure making it possible to assess and process routine information cost-effectively, the subject of building social intelligence capabilities is still being debated on a world-wide scale.

In the industrialised countries MIS at the operational and tactical levels have not been a problem for some time[34]. This is because people with the requisite experience and administrative skills became available to develop good operating procedures and experience gained initially at the operational level of MIS allowed experience to be developed to the tactical level[35]. At the same time hardware and software infrastructures were developing. Strategic level MIS pose deeper problems and only quite recently has there been a general push to move from the tactical to the strategic level MIS. These later became Decision Support Systems[36] and provide a basis for the building up of social intelligence.

2.9 *Governmental Information Systems*

At the national level, the governmental decision-making processes must be able to react to the environment at a speed compatible with that of the change in the environment. The feedback process has to be well instrumented, and since the amount of information in the feedback process is so vast, infotechnology should play an essential role in the systematic capture of information, its organisation, transmission and availability at the right time at all decision-making levels.

Infotechnology has been widely applied to administrative systems in Government. Typical applications have involved high volume transaction processing such as benefits payments (e.g. social security), tax collection, census of population, trade statistics and accounting. Computers are also being used in the public administration area for planning, decision-support[37/] and information retrieval[38/]. The large potential for office automation in this area is being increasingly recognised. Infotechnology offers wide scope for efficiency, for conservation of resources, and for enhancing decision making capability and organisation structure in the Government services. In support of this view, Friedrichs[39/] indicates that about 75% of jobs in public administration can be formalised and 38% automated. The increasing pressures being experienced in relation to public finance will provide a significant impetus to the adoption of infotechnology in this sector in the industrialised countries.

2.10 *Defence*

Military applications of infotechnology have a basic significance[40/]. Indeed some of the earliest computers were used for military applications and the semiconductor industry had its origins in the US principally in the defence and aerospace sectors. The demands of the military, together with the aerospace sectors for devices of high performance and reliability led in time to the emergence of the silicon transistor and later to integrated circuits [41/]. Modern weapons' guidance and controls, as well as military communications, command and intelligence are highly dependent on advanced technology. Without microelectronic aids, missiles would be useless. The extent to which a country can defend itself is to a large degree determined by infotechnology-based systems and equipment and these systems and equipment in turn are a crucial factor in global-power balances[42/].

2.11 *Factors Affecting the Diffusion of Informatics in Industry*

The general consensus is that even in the industrialized countries the diffusion of informatics must continue to be gradual, if only on account of the inbuilt inertia of existing industrial operations. Factors inhibiting developments include:

- heavy capital investment in existing plant;
- shortage of investment capital;
- industrial relations problems;
- shortage of skilled personnel;
- availability and cost of sensors and actuators;

- technological constraints.

The motivation for informatic innovations is primarily economic and the factors involved include:

- saving of labour;
- saving of energy;
- saving of materials;
- improved production control;
- improved process and quality control;
- increased flexibility in products;
- improved products;
- improved stock holding;
- improved pollution controls;
- reduced need for labour in hostile environments.

Costs

Infotechnology has been characterised by a persistent and rapid decline in costs reflecting the substitution of microelectronic for discrete components. For instance, over the last decade, the cost per bit of computer memory for successive generations of RAM chips has, according to Noyce[43], been declining at an annual rate of 40% from 1973. As well as a fall in the price of the components themselves, less labour and materials are required for interconnections, less intermediate testing is required and they are cheaper to operate and maintain. Electro-mechanical devices have not experienced the same decline in price as electronic devices and therefore peripherals, including sensors and actuators, in many cases are still quite expensive. This is reflected to some extent in the present overall

low level of industrial automation. While telecommunications prices do not appear to have fallen as rapidly as other electronic-based products, the available data on price trends suggests that equipment prices have increased considerably less rapidly than prices for all manufacturing[44]. Thanks to improvements in transmission and switching technologies, communication costs per circuit mile are steadily declining[45].

2.12 *Total Impact on Society*

A great many articles and books have recently appeared on the impact of infotechnology on society. Three views can be distinguished which have been called the micro-sectoral, macro-sectoral and structural views[46].

The micro-sectoral view, which is prevalent in North America, of the societal impact of infotechnology emphasises the role of telecommunications. By creating the possibility of global information systems coupled with local decision making, the impetus towards urbanisation can be reversed. In this way a fundamental change in society could occur.

The macro-sectoral view, which is prevalent in most of Western Europe and in parts of the USA, moves away from communities to the more general concept of information. Porat[47] found that over 50 percent of the US labour force were engaged in information activities and that these activities constituted 45 percent of the GNP. Similar results were subsequently obtained for other OECD countries. The

inference is that we are moving towards a global information society.

A wider view still, the structural view, which is prevalent in Japan and France, focuses on the changes in 'process' arising from the application of infotechnology, including changes due to robotics, office automation, etc. Changes in process have the potential to affect every aspect of economic activity and indeed our life style.

Bell[48] has discussed what he calls the post-industrial society. This envisages a change from a goods producing to a services society, a shift in the nature of research from a primary interest in products to a primary interest in the properties of materials, and the emergence of a new intellectual technology as a key tool for managing complex organisations. Infotechnology is clearly basic to the post-industrial society.

Society is subject to change from many sources. The precise role of the technological component in this process is far from being clearly understood.

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3. IMPLICATIONS OF INFORMATICS FOR PRODUCTIVITY AND EMPLOYMENT

3.1 *Statement of the Issue*

Discussion of the issues addressed in this Chapter has to date concentrated on the industrialised countries. The Dublin Conference on Informatics and Industrial Development placed these issues in a Third World context[1/]. Significant reductions in labour requirements and increased productivity, due to the application of infotechnology, have occurred in the industrialised countries. Examples are the cash register and telecommunications industries.

In this connection Narasimhan[2/] points out that technology plays two roles in an economy: an *extensive* and an *intensive* role. In its extensive role it enlarges the sphere of industrial activity, creating new processes and products and thus also new jobs. In its intensive role it increases productivity and tends to reduce jobs (existing or potential). From the long-term viewpoint, both roles appropriately deployed should be considered positive and desirable.

The effects on total employment numbers, *at the macro level*, arising from applications of infotechnology are not straightforward. While technology is, and will increasingly be, an important factor, the level and structure of employment is also a function of business cycles, economic policy, the economic system, demographic factors,

the degree of resistance among workers to change, income distribution, etc. It is difficult to separate out these effects.

Infotechnology, by facilitating the production of new equipment and products and the development and improvement of services, gives rise to significant employment opportunities at the manufacturing level and at the end-user level. Such potential employment in manufacturing may only be valid in a very small number of developing countries as most manufacturing equipment may be imported. An increased capital requirement may cause a tendency towards a greater concentration of industrial production in the developed countries. The employment creation potential of the indigenous production of informatic products (components, computers, word processors, software, etc.) requires special consideration and is dealt with in Chapter 5. In relation to the employment implications of greater direct utilisation of informatics equipment, such as computers, this is likely to affect only a small part of the labour force[3/].

From a national viewpoint the use of infotechnology should be influenced by a number of considerations: for instance, the survival and reasonable growth of the firm through the production of competitively priced goods of a high quality; the employment of as many people as possible at sociably acceptable wages; the improvement of working conditions and an appropriate distribution of skills. To focus on a single consideration, such as the possible short-term adverse employment impact, may result in a distorted view.

To the extent that production increases compensate for increases

in efficiency and productivity, the application of infotechnology to industrial processes will proceed pari passu with an increase in employment. Of course, for given production levels, it may result in a reduced demand for labour. The question whether production will increase in step with efficiency increases will depend upon whether potential producers can find a market for the increased production. There is a strong desire for greater consumption in all countries. The problem becomes one of judging what products can be sold. Product developers will therefore play an important role. Many of these new products will be based on infotechnology.

External Effects

The application of infotechnology in a particular firm or sector of the economy has, through linkage, implication for employment in other sectors of the economy[4/]. Lower quality-adjusted prices should result. The consequential demand increases should stimulate employment. If, however, the home country does not take up the new technology as fast as other countries, then home demand for consumer goods may be diverted to imports.

Global Demand

Changes in the global distribution of purchasing power as a result of increases in the price of energy, and also as a result of wider access to technological know-how by newly industrialised and developing countries, have radically altered worldwide patterns of demand. A factor which contributes to a narrowing of developing countries' options is the technological push of the developed

countries and the consequential erosion of comparative advantages. Developing countries, therefore, being particularly dependent on foreign trade for economic growth, must orientate productive capacity to products and processes consistent with these changes in demand. Efficiency must be maximised in all sectors and, as stated, the role of product development assumes major importance.

A major difficulty is that some countries wish to maintain a surplus in the balance of trade. Therefore countries that incur large deficits in their balance of trade become highly dependent on foreign loans and investments and the uncertainties which these entail. The result is that demand in all countries becomes weaker than it otherwise might be and this, of course, adversely affects employment levels.

3.2 *Need to Consider Each Country Individually*

Many developing countries are fundamentally different in terms of supply of labour, capital, skills, foreign exchange, unemployment levels, etc. as well as in the philosophy of their government and economic systems. These and other factors such as size of individual markets, extent of foreign control including degree of integration with local suppliers of intermediate capital goods, etc., and level of indigenous technological capability make it difficult to assess the impact of infotechnology in relation to employment and productivity for the Third World as a whole[5/]. Furthermore many developing countries have dual economies, i.e. rural and urban sectors which are almost completely separate from each other. Historical circumstances and geographical position

are also relevant as well as the degree of specialisation existing. This latter aspect obviously affects the ease with which infotechnology can be incorporated into production processes.

The above factors which affect the overall environment within which any individual developing country introduces infotechnology, and within which their associated employment and productivity consequences arise, should be borne in mind in the general discussion which follows.

3.3 *Compelling Factors for Adopting Infotechnology*

There is really no choice as to whether or not to apply infotechnology[6/]. Developing countries can only survive in world markets if they follow the lead of developed countries and incorporate the new infotechnology into their products.

One reason for this is that the economic system which prevails over large parts of the world today is characterised by a decentralised decision-making structure. The fact that both income and survival are closely tied to the actions taken by the firm provides an incentive for constantly trying to increase productivity. As already pointed out, worldwide economic pressures exist for overall efficiency improvements, radical product innovation, etc. which informatics technology facilitates. Thus it is reasonable to expect that the application of this technology will continue to expand.

Infotechnology, appropriately applied, can facilitate qualitative and visual improvements in products, in particular through

miniaturisation. Such improvements can constitute a powerful factor in enhancing product competitiveness.

Even the sheltered sectors of the economy will not be able to avoid the wide-ranging introduction of infotechnology, since a significant element of competition is often present within these sectors.

3.4 *The Innovative Process and the Diffusion of Technologies to Developing Countries*

The pace and extent of the adoption of infotechnology in industry can be usefully considered from the perspective of the factors influencing individual firms in relation to decisions to adopt innovatory policies and practices.

As indicated in Chapter 2 informatics developments have a wide range of applications directly linked to manufacturing, e.g. production management; process control; design; and control of machinery (numerically controlled machines, robotics, etc.). Innovations in manufacturing - in many cases this will involve infotechnology-based equipment - are usually responses to perceived weaknesses in the manufacturing system: e.g. low labour productivity; machinery breakdowns; unavailability of skills; excessive energy consumption; inadequate quality of product; unsafe working conditions; etc. Just as a weakness can be attributed to a host of things so also multiple possibilities arise in relation to the selection of an appropriate solution and in relation to the manner of implementing the solution. Of course, factors such as capital shortages, lack of foreign exchange, skill and knowledge deficiencies will retard the speed of diffusion of

informatics-based technologies, especially in developing countries. The Dublin Conference on Informatics and Industrial Development[7/] identified a shortage of skills as a major barrier to the successful introduction of these technologies.

Elements of the industrial environment other than the technology itself such as production support, skill levels, training, industrial structure, management development, etc. are relevant in relation to industrial innovation. This, of course, does not mean that technology transfer or research and development is not of importance in the industrial sector.

A firm, or an economy, that is not positively committed to industrial innovation will usually decline. Even though it is primarily within the firm that the innovative process takes place, public authorities have the power to influence this in various ways: policies and attitudes towards foreign investments, trade and tariff policies, fiscal measures and support for R & D. In relation specifically to the application of infotechnology, a raising of the awareness within industry of the possibilities of the technology for improving products and processes is important.

Offshore Industry

Offshore facilities have largely comprised assembly operations and in general have not involved any highly technical stages of production. These assembly operations are now being automated. Large firms which are most heavily involved in offshore manufacturing will be able to compare the costs of producing in

low-labour cost developing countries with those of home-based production using advanced technology. A large share of offshore production could become less attractive in this way due to a combination of the effects of rising domestic wages in developing countries, tariff barriers, and infotechnology-based innovations in developed countries. On the other hand, it seems probable that some industries will choose developing countries as locations for establishing industries based on the new technology. This choice may be due to factors such as tax advantage, lack of labour resistance, lower start-up costs, cheaper capital, relative absence of restrictions on the use of manpower and the environment as well as low labour costs, particularly of educated labour.

Transfer of Technology

Improvements in the level of education in conjunction with the availability of technological information, could enable developing countries to produce efficiently at a world competitive level and thereby maintain an acceptable level of employment. The terms under which these transfers of technology to developing countries occur, and also the relationships and interactions between the centres receiving this technology in developing countries and the economy of these countries generally, are the critical factors.

Skill Requirements

Developments in infotechnology will certainly lead to changes in the demand for skills. The availability of appropriate skills is a factor in the adoption of these technologies. There are various ways in which the total of the required skills can be distributed

but these must be backed up by appropriate training capacities.

The Garment Industry

A useful perspective of the impact of infotechnology on employment and productivity in developing countries may be obtained by taking the case of a specific industry. An industry which is of importance to many developing countries in terms of employment, exports and development is the garment industry. The impact of infotechnology on this industry from the perspective of developing countries has been discussed by, among others, Rush and Hoffman[8/] and Rada[9/]. This industry has traditionally been highly labour intensive and very fragmented. The systems of management and organisation in operation have been at a basic level and the degree of technology used to support the production process has been limited. A tremendous variety of wearing apparel is produced and, due to low wage rates, developing countries have enjoyed a very significant degree of comparative advantage in a number of high volume subsectors. The infotechnology to automate many phases of the production process in the garment industry is available. Recent advances in microelectronics, based on the microprocessor, will increase the scope and flexibility for applying infotechnology in this industry and make it more economical to implement. This will, in due course, lead to changes in the skill and investment requirements of the industry and it will tend towards a higher level of concentration in the industry generally. Labour costs will become a less important factor. It is important therefore that developing countries take the potential impact of infotechnology

into account in the elaboration of their development strategies for the garment industry.

3.5 *Structural Shifts in Employment*

During the industrial revolution, in the last century, it was feared that the replacing of people by machines would lead to widespread unemployment. Some labour displacement did indeed occur. However resulting productivity increases generated real income increases. Demand expanded and new industries and service activities were created. Overall employment rose although its composition changed, with a shift from agriculture to industry and services. Now these latter sectors are prime candidates for the application of infotechnology. Unless therefore there is a massive expansion of new industrial products and new services, the industrial and services sectors will not be able to absorb labour displaced by industrial and office automation. The large increase in population since the industrial revolution, as well as the present sluggishness in economic growth, reduce the prospects of absorbing displaced labour.

Rapid structural transformation between sectors, while it provides the basis for desirable productivity and employment improvements in general, may also lead to social stress. Global changes in the pattern of demand together with informatics developments are likely to contribute to a general failure by the labour force to recognise and positively respond to the need for such transformations. The main feature of developed countries, in this area, has been the agricultural sector's reduced significance and the corresponding growth in the services sector. These structural changes have

occurred as a result of low growth in demand and large increases in efficiency in agriculture together with the reverse situation in the services sector, i.e. rapid growth in demand and sluggish increases in efficiency. If the efficiency increases in the services sector had been greater, the structural changes between the sectors would have been less. As an aid to reducing such rapid transformations, the use of the microprocessor to automate and improve the efficiency of the services sector would be advantageous. This would also help that sector to play a catalytic role in relation to the development of organic and self-sustainable industrial development generally. The movement between sectors could then to some extent by replaced by less socially disruptive movements within the secondary sector to meet changing patterns of demand for manufactured goods.

However, if developing countries were to import entire industrial processes on a turnkey basis, islands of high technology could result and the consequential social and economic strains of accommodating the type of imbalances which would then be a feature of the economy, would not be easy to predict.

3.6 *Conclusion*

The scope for applying infotechnology for increasing productivity in industrial processes is large and the potential impact of such applications on labour and skill requirements is very significant. At the national level it is difficult to separate out the employment effects of infotechnology from other determinants of employment. While the pace of diffusion of this technology will vary, there are compelling forces for adopting it to improve

efficiency and enhance productivity so as to maintain competitiveness. It is essential therefore that appropriate provision be made for these factors in the elaboration of industrial development strategies.

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3. Rada, J.F., Dublin Conference.

4. Stoneman, R., Dublin Conference.

5. See Dublin Conference, Section 8, page 430.

6. Kvale, O., Dublin Conference.

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4. INFORMATICS DEVELOPMENT IN THE THIRD WORLD

4.1 *The Constraints and Need for International Action to Promote Policies and Strategies*

There are many obstacles and constraints to technological development in the Third World. These include: massive illiteracy; extremely poorly developed communications infrastructure to support information transactions; lack of financial resources; massive unemployment; scattered rural communities; rapid population growth; general lack of infrastructures; lack of organised procedures to accept technology transferred from abroad; lack of basic capability for decision making and implementation in development matters.

Comparative statistics point up the problems. The Third World (including China) has three billion people - nearly three-quarters of the world's population - living on one-fifth of the world's income and with only 10% of the world's manufacturing industry. Illiteracy is typically around 50% and ranging up to 80% in a number of countries. The World Bank estimates that (excluding China) 800 m people are destitute and estimates (optimistically) that the figure will still be 600 m by the year 2000.

Narasimhan[1/] proposes that radically innovative, unconventional solutions will have to be tried in deploying infotechnology in the provision of education to eradicate illiteracy, health care to improve the standard of living, and community services to upgrade the quality of life for the geographically dispersed small communities of people in countries like India: the magnitude of the problem renders

conventional solutions infeasible.

Constraints on Diffusion of Systems Technologies

One fundamental constraint to the development of infotechnology in the Third World is that it largely belongs to the category of *systems* technologies. In order that such a technology be effectively implemented, it is necessary to coordinate a large number of interacting components to operate as a system[2]. In this regard, in addition to economic and technical feasibility, social and cultural feasibilities must also be considered, and these may be the most constraining[3]. Such a systems technology may be contrasted with the successful type of technology transfer in which a discrete innovation, such as a pocket calculator, is introduced that requires few new skills to operate while mobilising these skills towards new applications[4].

International Action

On account of the numerous obstacles and constraints, international action will be essential to assist in promoting the adoption in individual developing countries of appropriate policies and strategies for informatics development together with the establishment of appropriate national institutional arrangements.

4.2 *Technological Self-Reliance*

The principle of technological self-reliance for developing countries is now widely accepted as an essential pre-requisite, not only for

the rapid acceleration of their social and economic development but also to overcome their excessive technological dependence on the industrialised countries.

Technological self-reliance is defined as the autonomous capacity to make and to implement decisions and thus to exercise choice and control over areas of partial technological dependence or over a nation's relations with other nations. The need for operational strategies in this regard is pointed up by the fact that at present research on problems directly relevant to the Third World accounts for only something like one per cent of the total research expenditures of the industrialised countries[5/].

Self-reliance must be concerned with the long-term development of skills and resources and the independence to use them to meet national objectives[6/]. It should not be seen as simply a drive towards self-sufficiency in response to immediate pressures such as a shortage of foreign exchange.

The development and implementation of a strategy of technological self-reliance is a complex problem. It involves much more than the creation of national technology centres, improved access to foreign patents and know-how, the availability of capital to exploit them, etc. Social, economic and cultural interactions play an important role and there must be a will to communicate and cooperate at all levels[7/].

An appropriate programme of indigenous research and development is

an essential component of a strategy of technological self-reliance. Such a programme would not seek to duplicate the efforts of industrialised countries. To be cost-effective it should be very selective and concentrate on a limited number of assignments most relevant to the situation in the country concerned[8].

4.3 *Role of Informatics in Achieving Self-Reliance*

Informatics as a major concept on which action can be based to promote self-reliance has not yet received general recognition in international forums.

Informatics has cross-sectoral impacts. It is centrally concerned with the modalities of providing the right information to the right person at the right time, cost effectively, and irrespective of whether the medium of transmission is formal and infotechnology based or informal and word-of-mouth. The processes of information flow that support productivity are subtle and complex and not yet well understood or modelled, and it is here that the deepest informatic problems reside, and not in the relatively simpler domain of automating an information system on the basis of a well-structured model.

Services Sector

Industrialisation and economic development have always been accompanied in the developed countries by a structural shift of labour from the primary and secondary production sectors to the tertiary or services sector[9,10,11]. The critical importance of

developing the services sector in developing countries is pointed out by Narasimhan[12]. The commodity in which this sector mainly deals is information: e.g. in banking, insurance, agencies, industrial consultancies, etc. The growth of demand for specialised information services of all kinds is part and parcel of a balanced development of a society. This in turn leads to increased specialisation and professionalisation of the occupational categories in the services sector, the essential aspect of which is increased "information consciousness". In the early stages of industrialisation the service occupations are in-house, but as industrialisation advances and the service occupations become more specialised and professionalised, they are transformed into industries in their own right.

According to Narasimhan[13], however, over a 50 year period during which time a comprehensive industrial base has been built up in India, there has been virtually no structural shift of the labour force from the traditional occupational categories. As a result a very large proportion of the industries operate without benefit of such specialised information service inputs as would exist in a services sector. These missing occupational categories are precisely the ones that would contribute to the efficiency and productivity of the primary and secondary production sectors.

Thus in India, as in other developing countries, the industrial sector remains isolated and unintegrated into the national socio-economic system. Many occupational roles that should accompany a balanced industrialisation and provide diverse employment opportunities are unavailable. This also shows up in the form of

low levels of information consciousness in the entire spectrum of socio-economic activities.

In regard to the development of the services sector itself as a sector of the economy, it is an interesting point[14/] that increases in productivity in this sector come about mainly through the application of infotechnology, embodied in the form of microelectronics equipment. The technology results in decreased labour growth and is most evident in the office automation area. Since, as has been pointed out above, the occupational roles in this sector in developing countries have still to be provided and since productivity increases in this sector are essential in expanding the ongoing economic activity elsewhere, such a so-called "intensive" role for the informatics activity should be considered positive and desirable.

In facilitating the development of capabilities in information handling, in the interest of creating self-reliance and having regard to the multiplier effects involved, the development of the information-intensive sections of the services sector could be seen to be one of the most fundamental ways[15/] in which industrial growth could be stimulated.

Social Intelligence

At the heart of the informatics concept is the notion of information and feedback control within an appropriate time frame. This is so, whether we are thinking of the automated control of an industrial process or, at the other end of the spectrum of applications, the strategic control of a corporation, or of a nation[16/]. Information

and power are two sides of the same coin[17] and basic to self-reliance.

A basic informatic problem, both in industrialised and developing countries, but acute in the latter, is attitude to information[18]. If the attitude to information is indifference, then the contribution of information resources to productivity will be less than fully effective. In other words, more basic than providing the answers to the questions is stimulating the questions to the answers[19].

The basic problem is to inbue information with value in the eyes of the problem-solvers[20]. The motivation will then be created to develop the appropriate information networks as a basis for the generation of a social intelligence[21] and effective decision making[22] at every level.

4.4 *Models for Informatics Development*

The Brandt Report[23] states: "A refusal to accept alien models unquestioningly is in fact a second phase of decolonization. We must not surrender to the idea that the whole world should copy the models of highly industrialized countries."

There is no reason to expect that the normal informatics applications in the industrialised countries would have much relevance to the problems of the developing countries. In the past much harm has resulted from informatics developments in Third World countries being based on the transfer of ready-made solutions to unstructured

problems. This has often also involved the transfer of value systems and ways of thinking of the West.

Appropriate models will have regard to the factor endowments, relative abundance of labour and scarcity of physical capital and skills, of the developing economies, and to a policy of self-reliance: the long-term development of skills and resources and the independence to use them to meet national objectives[24/].

Revolutionary advances in infotechnology create new possibilities in all sectors of the economy. Informatic products can change the entire structure of an industry. A good example in the West is the banking industry which is in process of radical restructuring[25/]. But in the developing countries new and innovative applications are still waiting to be discovered.

An industrial strategy of decentralisation becomes feasible due to the capabilities of decentralised information systems with connection where appropriate to major centres. Production in a larger number of smaller decentralised units becomes economic and may be advantageous where the size of the market is also small. This strategy in bringing industry to the people in rural areas would ease the increasing problems of urbanisation.

Again informatic products can enable an unskilled person to perform a sophisticated task which otherwise could only be performed by a highly skilled person. Such applications may provide a short-cut to acquiring skills that do not yet exist in developing countries[26/]. In

this way, instead of eliminating manpower, informatic applications can increase employment and enhance skills.

Selection of models must also take into account the priorities in particular developing countries. Different criteria will apply in different countries, but in general because of the labour force distribution, with typically three-quarters in the rural sector, developments in this sector will have highest priority to increase decentralisation and balanced economic growth and utilisation of manpower. Priority will also be given to informatic application in small scale industrial enterprises which in a developing country might typically account for fifty per cent of total industrial production. More specifically, efforts must be directed to greatly develop the services sector to serve the small scale enterprises as a channel of appropriate infotechnology transfer[27/].

Information handling capabilities constitute the nervous system of a society and information is the ignition key to innovation and self-sustaining development, drawing the inventiveness and adaptiveness of local artisans, small entrepreneurs, etc., into a national development effort. In-depth studies will be required for the development of detailed models of appropriate information services and systems and of national information networks to meet the needs of a variety of end users. These include R & D personnel, technologists, engineers, industrial managers, economists, planners, investors, financiers, entrepreneurs, market analysts, sales personnel, industrial consultants, government decision makers.

Models for national communications systems must have regard to the changing telecommunications technology and changing costs. These

changes increase the available options, ranging from very low-cost systems, based e.g. on a combination of subscriber radio point to multipoint microwave system and buried cable, to the highest technology based on satellite transmission.

4.5 *A Conceptual Framework for National Informatics Development*

Informatics development is a dimension of technological development which in turn is an integral part of national economic development. National policies and strategies in this regard require to be developed.

While patterns of economic development will vary from country to country, depending on a number of factors including resources, geography and skills of the population, it is now recognised that it involves a transformation of the entire economic and social structure[28]. It means creating a more diversified economy whose main sectors become more interdependent. The overall national policy objectives may include:

- promotion of national self-reliance;
- employment creation;
- development of education and training;
- industrial growth.

Technological Development

Technology is recognised in industrialised countries as a central, critical factor in development and technological development is built into national development strategies to achieve policy objectives, whether military, economic or social. In developing countries, on the

other hand, the importance of technology as a factor of development is largely unrecognised. As a result, technological development strategies have been lacking with the consequence that in the developing countries industrialisation has tended to be accompanied by growing technological dependence on foreign sources[29/].

This contrast in attitudes to technology between industrialised and developing countries suggests that the reduction of technological dependence should be central to national development policy in the latter. Technological development should be a dimension of development and this means essentially the building up of a basic capability for decision making and implementation in technological matters[30/].

Within overall national development policy, the specifically technological development policies should thus include:

- promotion of national capability for production and dissemination of technologies;
- promotion of national capability for technological innovation;
- development of an organised process for technological transfer from abroad.

Informatics Development

Informatics is not just one sector of technology that can be considered in isolation. It is rather a dimension of technological development with cross-sectoral impacts[31/]. In line with the technological development policies enumerated above, more specific policies relating

to informatics may now be enumerated on two levels: (i) operations; (ii) infrastructures.

(i) Policy objectives at the operations level:

- promotion of indigenous hardware and software industries;
- identification and promotion of priority application areas;
- promotion of innovative applications;
- development of management decision support systems;
- development of governmental information handling systems.

(ii) Policy objectives at the infrastructures level:

- promotion of awareness, education and training;
- development of national communications;
- development of national industrial information services and systems;
- promotion of the industry related services sector.

The attainment of each of these policy objectives will require strategies at sectoral or national level as appropriate. One major national development strategy will be the setting up of appropriate institutional arrangements for the promotion, coordination and review of these specifically informatic policy objectives and their corresponding strategies, national or sectoral.

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5. NATIONAL ACTIONS: POLICIES FOR INDIGENOUS PRODUCTION OF HARDWARE AND SOFTWARE

The principle of self-reliance[1/] has a fundamental application to the question of developing indigenous production of hardware and software in the Third World. This principle does not imply that efforts must be made at all costs to achieve the greatest possible degree of indigenisation. What it does imply is that the competence should be developed that will enable the country to make informed decisions regarding the sectors of the informatics industry that it would be desirable to develop on the basis of carefully selected objectives.

The development of an operational strategy in regard to indigenous manufacture is of special importance on account of the rapidly changing technology. This keeps changing the options which must be constantly re-examined in the light of the priority needs of the country.

5.1 *Consequences of an Indigenisation Policy*

The desirable consequences of an indigenisation policy in informatics may be considered under three heads.

Firstly there is the consideration of the direct economic benefits accruing to the country through participation in an industry that has become, as a result of a period of extremely rapid growth, one of the three largest world industries alongside energy and transport.

Secondly there is the political consideration of reducing the risk of too heavy a dependency of a country's industrial sector on imported 'nformatic products.

The third and most fundamental consideration is that the informatic products actively marketed by the industrialized countries are not appropriate to the needs of developing countries, which in only to be expected since the needs of the developing countries in this regard have hardly been examined as yet.

There is no doubt that an examination of priority application areas would show quite different needs between developing and industrialized countries. Indeed, differences in priority of applications would obtain between individual developed and individual developing countries. Kalman[2/] contrasts in a number of examples differing priority applications in the industrialised and developing countries. The approach to the promotion of indigenous capabilities in the area of indigenous production of informatic products should clearly be based upon the need to ensure that the supply of such products is geared specifically to local requirements.

5.2 *A Selective Approach*

The changing structure of the informatics industry[3/] provides opportunities for enterprises to enter the production of hardware at any of a number of different levels, corresponding to the key decision stages in the manufacture of a product: the components, boards, enclosures, and full systems.

Thus a country can adopt a policy of selectivity in regard to imports and not necessarily try to manufacture everything. Since there exists a large number of manufacturers in many countries offering high quality and low cost components and equipment, a country can pursue an optimal policy of selection. Thus without becoming too dependent on one country or one manufacturer, imports of an appropriate mix of components, sub-systems, equipment, etc. can be undertaken. Such a policy contributes to self-reliance by long-term development of skills and resources and the independence to use them to meet national objectives.

Gupta[4/] cites application areas which contribute directly to Indian national development: process control, freight wagon identification, power systems control, flood warning systems. Computers are an integral part of such dedicated systems. Today in developing countries most of these systems are supplied on a turn-key basis by a limited number of manufacturers from the industrialized countries. While the hardware costs are going down, the costs of manpower and software are increasing. There is no reason why the activities making up the bulk of the cost, systems integration, interfacing, installation, commissioning, maintenance, software development, training, etc., should not be done locally on a national basis. Such a systems engineering approach retains the advantage of obtaining the latest and most reliable hardware and yet depends for a large portion of the activity on national resources and skills. It depends of course on the availability of technical skills in the country. India, for instance, has skills to perform many of these activities and efforts in this direction have been going on there for a number of years.

5.3 *An Institutional Basis*

The development of an indigenous capacity for the production of hardware and software requires an institutional basis which is national in character, independent in approach and with the capability to render total support. Again, India provides a case study.

The Government of India set up the Computer Maintenance Corporation Limited (CMC) in 1976 to provide one-point total support to computer users[5/]. CMC now works closely with the Central Electrical Authority, the Meteorological Bureau, etc., to introduce computers for control and monitoring purposes. The approach could be extended to any large-scale applications in order to integrate the best hardware available, imported if necessary, while developing the software internally, thus retaining full independence, flexibility and control, and at the same time reducing costs. All support services including maintenance for imported hardware are provided by CMC. These services include site consultancy, site preparation, installation and commissioning of systems, software support, systems advice, user training, applications development.

5.4 *Hardware*

Development of hardware necessitates large scale investment and requires government support. This may take the form of measures, such as import controls and subsidies, to protect indigenous producers in the home market. These measures necessitate an additional cost to either the tax payer or the final purchaser and at the same time potential advantages from allowing a wider choice

in the home market through a less restrictive import policy are foregone. Government support may also take the form of assistance with research and development, grants for training and upgrading of skills, assistance in defraying operating costs, etc. which are more directly aimed at making indigenous producers competitive with imports. Even in the case of small computers, an indigenous supplier has significant operating costs in providing a satisfactory level of user support and assistance in order to penetrate the home market[6/]. A producer who is successful will build up an installed equipment base sufficiently large for local specialised firms to grow around it producing 'plug-compatible' products and services (terminals, application packages, software, maintenance, etc.) and he will not have to supply the whole range of hardware and associated products and services himself.

The option of a joint arrangement between a developing country and an industrialised country in relation to hardware manufacture is worthy of consideration. This can range from labour-intensive offshore assembly to a more genuinely joint approach where some of the strategic production areas such as research, design, marketing, manufacture, etc. are carried out in the developing country. If foreign companies become more integrated into a host country's economic structure, the quality of the employment which they provide and their capability to become more innovative in the host country will increase and provide, in time, a training ground for local entrepreneurs[7/].

Joint arrangements, of course, inevitably leave the developing country in the position of a junior partner. This is not a fully

satisfactory situation and for instance offshore assembly does not generally lead to genuine integration in host countries. Regional co-operation is another option. Arcaraz refers to the Latin America Free Trade Association where the tole of producing and exporting machinery for information processing was assigned to Brazil among the members of that association, computers being then imported duty free by these countries.

Wholely indigenous manufacture of hardware is very expensive and the likelihood of a manufacturer in a developing country reaching a self-sustaining level of operation is slim, particularly where the country has not a sufficiently large home market for domestically produced informatic hardware. All or some of the following - maintenance, systems integration, commissioning, installation, interfacing, etc. - are generally a more practical proposition than attempting to manufacture a full range of hardware products and should be actively encouraged where possible.

5.5 *Software*

Indigenous software production is more immediately attractive than hardware manufacture. As Hanna[8/] points out, the software industry does not have a high demand either for direct capital investment or for physical infrastructure (with the exception of educational facilities and, in some circumstances, telecommunications) and is expected to grow extremely rapidly in the future.

Developing countries have special requirements in relation to informatic applications. Jain[9/] characterises these special requirements as deriving principally from the important position

of the rural sector in the economy, the small scale of industrial units, and instability in the supply of basic industrial inputs. Therefore, simply transplanting applications software from developed to developing countries will not in general be appropriate.

Governments can take effective measures to promote an indigenous software industry. Kalman[10] lists some specific measures including: direct financial support by Governments to assist software firms to acquire computer hardware and to undertake training; reducing the tax liability of such firms by an amount sufficient to meet the cost of maintaining installed locally produced software; legal copyright protection for software; and establishing registers of software in order to avoid unnecessary duplication.

Suitable institutional arrangements to manage and coordinate indigenous software production (including supporting manpower training arrangements) and to ensure that the software produced is of a high quality and that it is fully compatible with national application priorities are a pre-requisite.

Singapore is an interesting example of a country which is taking steps to reduce reliance on labour - intensive, low productivity industry by promoting high technology sectors. Infotechnology is one of the high technology sectors earmarked for development[11]. In particular, a major drive is underway to establish a significant local capability in software production. Software was chosen in preference to hardware because it was felt that this strategy would

be more appropriate than attempting to compete with the major industrialised countries in an established area of infotechnology such as the manufacture of hardware. A massive training programme in software skills is being launched in order to ensure a steady supply of high quality manpower. Education curricula are being reviewed and new training structures established. Incentive schemes to encourage industrialists to undertake software production are being formulated. There is provision for external assistance, where appropriate. It is too early to assess the effectiveness of the strategy being adopted by Singapore. However, it should be noted that Singapore is not typical of developing countries. In areas such as education, literacy and employment, it is on a par with highly industrialised countries. For this reason the experience of Singapore will require careful interpretation before it can be drawn upon in the development of models for developing countries.

NOTES AND REFERENCES FOR CHAPTER 5

1. See Chapter 4.

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3. See Chapter 2.

4. Gupta, P.P., Dublin Conference.

5. Gupta, P.P., op, cit.

6. Arcaraz, C.E., Dublin Conference.

7. Hanna, D.P., Dublin Conference.

8. Hanna, D.P., op. cit.

9. Jain, P.D., Dublin Conference.

10. Kalman, R.E., op. cit.

11. Iau, R., Dublin Conference.

6. NATIONAL ACTIONS: POLICIES FOR INFORMATIC INFRASTRUCTURE AND SOCIAL DEVELOPMENT

Introduction

A national informatic infrastructure determines a country's capacity to harness infotechnology for the benefit of social and economic development. It provides the essential link between national strategies and policies, together with the international dimension, on the one hand, and individual applicaitons in industrial,rural, government, services, etc. sectors on the other. Education and training is a pivotal element of infrastructural capacity. Other important elements include information services, communications, and research.

6.1 *Constraints*

A number of factors which significantly contribute to the development of an appropriate infrastructure in the case of industrialised countries, are not generally present in the case of developing coutnries[1/]. A mature technical environment characteristic of a developed country includes, for instance, a high degree of competence among users of infotechnology, at least some local production of informatic hardware and software and high level technical support and maintenance services. In addition software and associated documentation are written in the languages of the developed countries. The smooth evolution of informatic applications to progressively sophisticated levels, in step with technical and industrial innovation, such as occurs in developed countries, is

unlikely to occur in developing countries.

The social and administrative systems of developing countries are often characterised by decentralised, small volume data capture on the one hand and centralised decision making, on the other, requiring specially tailored informatic solutions. There are many application environmental factors of special relevance to these countries. Typical examples are instability of electricity supply, poor quality data transmission lines and climatic conditions.

Informatic hardware manufacturers sometimes provide only basic representation in developing countries and do not provide comprehensive maintenance services. Structures and systems must be developed to ensure an adequare level of maintenance. The carrying out of necessary repairs, location of spare parts, etc. must be satisfactorily provided for. The incorporation of back-up facilities in informatic applications and the direction of attention to quality and reliability of systems is very important in the case of developing countries in order to cater for their relative technical immaturity, as well as for the irreversibility, for all practical purposes, of informatic applications.

In developing countries, an informatic data collection and preparation application may not be replacing a manual mode of operation[2/]. Quite often it will be a completely new application. Most of those operating the application may not have come into contact previously with the disciplines necessary for such work.

The nucleus of a workforce has not evolved in many developing

countries. Because of this, the overall balance of normal informatic training, as obtains in the case of industrialised countries, must be modified in order to cater for the needs of developing countries. On-the-job experience before the realisation of certain basic capabilities cannot be assumed as the opportunities for acquiring such experience are not available[3].

6.2 *Awareness, Education and Training*

Various international conferences and reports have underlined the importance of the planned application of infotechnology for national development[4,5,6]. Notwithstanding this, the applications in developing countries have been, relative to developed countries, extremely limited.

In this regard, and as part of a more fundamental move to render existing educational systems more relevant to socio-economic development[7], there is scope for imaginative and innovative programmes in formal education, designed to increase the level of informatics awareness.

In developing such awareness programmes, study should be made of the steps that have already been taken in many of the industrialised countries[8]. These steps include the organisation of numerous seminars, production of publicity materials including specially commissioned video films and books, substantial media coverage, consultations with trade unions, introduction of small computers in

schools.

Awareness and education are needed in the first place in order to create the political will to develop the massive manpower training programmes that are required in the developing countries if the potentialities of informatics are to be realised.

The countries of the Third World generally suffer from shortages of critical skills required in the industrialisation process: engineers with agricultural expertise and managerial skills, industrial designers, production and process engineers, engineering craftsmen, food technologists, quality-control personnel and management accountants. For most of these people, informatics related training is also desirable, in addition to the training of professionals in computer skills: systems analysts, organisation and methods experts, programmers, operators and data preparation staff. Professional training in this area has not generally reached a high local standard. The type of training required is often not recognised and the decisions about training may even be left with the hardware manufacturer, with a consequent emphasis on operational skills and neglect of management skills. The separation out of the costs of hardware, software and training ('unbundling') has, at least, led to the recognition that training is not free.

The performance of a system depends on the one hand on its concept and design and on the other hand on the environment in which it operates[9/]. The operating environment includes, in particular, the human element interacting with the system in various aspects. Education and training are the means by which the efficiency and

effectiveness of the vital human component of a system is optimised.

There is a lack of information on the informatic education and training needs of individual developing countries[10]. This makes it difficult to formulate appropriate programmes in this area. Informatics is a new field. Many of those engaged in it were previously concerned with some other area. This has led to some inconsistencies and lack of clarity in subject nomenclature which further adds to the difficulties of formulating a programme[11].

In order that the expenditure of scarce resources on education and training will not be negatived by "brain drain", the Government may have to promote policies in relation to the remuneration of local public sector and university-level institutions so that these institutions will be able to retain informatic staff of sufficient calibre[12]. Another area for Governmental consideration is the possible regulation of private informatics training schools in order to optimise the contribution of such schools to national informatics development. A national framework of informatic education is required, at all levels including advanced courses for specialists, in order to avoid unnecessary duplication of resources. In some cases a regional framework may be advantageous. Education and training centres must be equipped with appropriate hardware and software. In this connection the use of individualised teaching packages may be very effective. Adequate library and reference facilities should be provided to support informatics programmes.

An appropriate balance between a theoretical and a practical

orientation should be adopted in relation to education and training. Programmes should be kept up to date with developments in infotechnology. Procedures for assessing competence in the area of informatics should be developed. Where aptitude tests are used they should reflect local and regional circumstances[13]. Training in the key areas of data entry and data control needs to receive special attention since, as already referred to, many of the people involved will not have been previously exposed to the type of discipline required.

While expatriate expertise has a role to play in selecting, developing and implementing informatic applications, in the final analysis, in order for the high investments in such applications to be fully economic, local expertise must be available to resolve the day-to-day problems that arise from time to time in operating even the best designed applications[14].

Different categories of personnel interacting with informatic applications require different relative balances between education and training[15]. Education is primarily concerned with the development of a person's character or mental powers. Training, on the other hand, is generally more specific, of a shorter time span, and is concerned with bringing a person to a desired state of efficiency by instruction and practice. For data preparation, machine operating, programming, etc. staff, a high degree of training is required in conjunction with a more limited amount of education. For research, design, management etc. staff, a high degree of education is required supported by a more limited amount

of training. The distinction between training and education is also relevant to considerations of the institutional arrangements for implementing educational and training programmes.

Training for New Entrants

Scott[16/] sets out a number of aspects appertaining to the present position in relation to education and training for new entrants to the informatics profession in Africa including the following:

- Most new entrants to the profession only attend computer vendor courses;

- There has been considerable implementation of post second level courses and also the emergence of some activity at secondary school level;

- There has been considerable implementation, at under-graduate level, of service courses in informatics for science and business students generally;

- The main developments have been at the post-graduate level and a number of scientifically-oriented and business-oriented post-graduate diploma courses have been implemented;

- Training courses in systems analysis and design are being run at regional level;

- User education appears to be comparatively neglected.

External Support

External consultants have a role to play in the development of informatics education and training programmes in developing countries. For instance, they might be called upon with advantage to identify the present and potential availability of suitable local informatic manpower, to cost alternative training strategies and to engage competent expatriate informatic training specialists to implement selected strategies.

In general, the consultants' role should not extend to the actual setting of the objectives for which the training strategies, being developed by those consultants, are designed to achieve. Such objective setting, and also choices between individual training strategies and broad programme options, is a matter for the Government agency charged with informatics policy[17]. This, of course, presupposes that the appropriate government agency has been able to develop a sufficient level of internal capacity to fully elaborate the objectives required. If this is not the case, external consultancy support will be necessary in this area also, either through the cooperation of international organisations or otherwise. Such strategic decisions must in due course be accurately reflected in executive decisions such as number and size of training centres, the balance between general and specific training, the broad thrust of the disciplines to be taught, etc.

External Training Personnel

To secure training personnel of the appropriate calibre, it may be necessary to engage expatriate personnel, usually on a contract

basis. Costs associated with employing such personnel include: the drain on foreign exchange; any increased salary levels over those obtaining in industrialised countries and, by definition, over those paid to local workers, in order to attract appropriate staff; overheads such as those attributable to the relatively short turnover period of such staff; the impact of demonstration effects of the high standard of living of such personnel on the local community.

Prior to engaging such training personnel a full cost benefit exercise should be carried out[18].

Training vis-a-vis Line Management

In the context of a national programme of indigenisation of local employment, there might be a need to modify the traditionally supportive and subordinate role of training personnel vis-a-vis line management. Understandably management's attitude to the trainers might be conditioned more by the fact that it is their own replacements that are being trained rather than by the potential contribution of training to the success of the enterprise[19].

6.3 *Industrial Information Infrastructures*

Information handling capabilities, whether formal or informal, are crucial to industrialisation. In the industrialised countries such capabilities have been observed growing hand-in-hand with industrialisation right across the board, in all sectors[20].

In the developing countries there is a need for an institutional response to the problem of carrying out those supporting information activities that have generally not emerged and which the main product firms often have to provide for internally, leading to duplication and excess capacity.

Information services and systems of national information networks are required to coordinate sectoral growth and meet the needs of a variety of end users. The type of information needed covers socio-economic data, financial opportunities, market situations, equipment availabilities, management practices, patents, legislation, etc. It has to be continuously updated and obtained from a variety of sources, at national, regional and global levels. It is transmitted to end users in many forms ranging from oral communication to computer printouts.

Sozen[21/] points out, in the case of Turkey, that often the required information already exists, but is not readily available, in one or other of a number of existing unrelated bodies and that the most economical approach would be to link these up into one new central agency.

Communications Infrastructures

In the process of development, a careful balancing of social forces is necessary. In order for these interrelationships to function effectively, efficient communications systems are necessary. Infotechnology, from the printing press, through electrical communications devices, to modern telecommunications systems, has

played, and continues to play, a crucial role in the provision of efficient communications capabilities. However the gap between successive major infotechnology-based communications developments has shortened considerably. For instance, the gap between the development of the printing press and the development of the telegraph and the telephone was much longer than the gap between the development of the telegraph and the telephone and the development of worldwide satellite-based data transmission systems. If the maximum benefit from successive infotechnology-based communications advances is to be realised, social groups and organisations must carry out appropriate adjustments. The process of social adjustment is traditionally very gradual. The pace of recent developments in communications, on the other hand, has been very rapid. As a result, adjustments in social organisations are lagging behind. For instance, modern inexpensive, energy-efficient communications systems offer the opportunity of small effective decentralised decision-making units[22/] yet the trend towards vast industrialised urban sprawls continues. Appropriate policies are necessary to accelerate the pace of appropriate organisational adjustment so that the maximum benefits from infotechnology-based advances in communications systems are harnessed for the wellbeing of nations.

In order for telecommunications to be appropriately integrated into an economy's infrastructure it is necessary to consider suitable institutional arrangements, to adopt a systems approach and develop a proper planning framework. Adequate funding must also be ensured as the investments costs are high. The institutional arrangements should not be unnecessarily bureaucratic and should be sufficiently

flexible to allow for an imaginative approach to be adopted. A plan is important because the payback period can extend to several decades.

6.4 *Research and Development*

An adequate R & D capacity is an important prerequisite for realising a measure of self-reliance in the field of informatics. It provides a means of keeping abreast of technological developments and facilitates the cultivation of innovative entrepreneurship. Most R & D takes place in the developed countries. Because of severe resource constraints, developing countries should select a few R & D assignments most relevant to their requirements and allot available resources to funding these[23/]. R & D efforts should not simply reproduce the efforts of the developed countries. Their aims should be based on an assessment of long-term advantage. Most R & D is government sponsored. There may be scope for promoting some R & D industrial enterprises through the use of carefully designed financial incentives.

Scott[24/] proposes that an informatics R & D programme appropriate to the needs of developing countries could begin with selected projects such as: the implementation of dial up telecommunications facilities for data transmission purposes; the automation of national university libraries; the application of portable microprocessors, e.g. in the fields of computer-assisted instruction, medical diagnosis and farm management; the impact of word processors on traditional urban employment.

Shortages of qualified advisory informatic personnel, in particular

in higher education and central government informatics centres, is seriously impeding the application of informatics in technical areas, e.g. the creation of medical data bases, the processing of satellite data, etc.

Institutional infrastructure appropriate to research and development in informatics technology must be provided. These might involve attaching laboratories to university-level institutions in different regions of the country with each laboratory being allocated a clearly defined area of interest.

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22. Byrnes, T.J., Dublin Conference.

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7. INTERNATIONAL ACTIONS

7.1 *The Scope for International Actions*

Although sustained studies of the deep-going processes of the development of productive forces are still lacking, particularly with respect to the Third World, nevertheless there is sufficient evidence[1/] that the quantity of information activities, however measured, that support productivity in the industrialised countries differ by orders of magnitude from that in developing countries. National self-reliance depends upon the availability of informatic infrastructures and international actions under many different heads will be essential in the promotion of these infrastructures.

In a particular country these actions are all inter-related and will be mutually reinforcing and should be approached in a systemic manner[2/]. They include the promotion of:

- national policies and strategies including institutional arrangements at national level;
- awareness, education and training;
- information infrastructures including industrial and technological information transfer services and systems, R & D, industrial extension services and the services sector;
- communications infrastructures;
- hardware and software industries;
- new products and processes;

- applications including governmental information handling systems, management decision support systems, and innovative industrial applications with special reference to small scale industrial enterprises.

Global Studies

At another level, international organisations could usefully carry out global studeis, seminars and workshops to assess needs. In this way in-depth knowledge about models for informatics development that are appropriate for the Third World may be generated. As pointed out in Chapter 4, models that have been developed in the industrialised countries cannot necessarily be transferred. Such studies are also required to identify programmes and to pinpoint where action should be taken to achieve maximum results. Cooperation with non-governmental organisations in carrying out such studies can often be advantageous.

Categorisation of Developing Countries

A categorisation of developing countries may be required so that the actions can be tailored to groups of countries. Thus it may be appropriate in some cases to take contiguous countries, such as the Andean Group or regional country-groups in Africa and Asia. On the other hand it may be relevant to consider countries at a similar stage of industrial devleopment, such as Brazil, India and Mexico. Such groupings could, for certain heads of action, be based on a simple typology of the developing countries using the features of population size, geographical area and population density, per capita income, economic growth rate, internal income distribution, availability of natural resources[3/].

In this connection it may be noted that, with reference to the general development of informatics, typologies of developing countries have been suggested in the literature[4,5]. But in connection with actions under specific heads which is our concern here, such typologies would not necessarily have operational significance.

Global Cooperation

To achieve any effect it will be essential for UNIDO, with a focus on industrialisation, and the other international agencies that are concerned with other aspects of informatics, IBI, UNESCO, ITU, UNCTAD, World Bank, FAO, ILO, etc., together to mount a global onslaught aimed at the national governments, educational systems, R & D and industrial infrastructures. Such an effort could be integrated with the purpose of World Communications Year 1983 (WCY83) proclaimed by the UN General Assembly in November 1981, and the goals and initial achievements could be reported at the SPIN II Conference and the UNIDO General Assembly, both in 1984.

7.2 *National Policies and Strategies*

In this and the subsequent sections we now consider international actions under the various heads.

In 1971 and 1973 in two reports of the Secretary General to the United Nations[6,7] it was recommended that "each developing country should formulate a broad national policy, consistent with

its national goals, on the application of computer technology", and a set of recommendations were set out.

Since that time the Intergovernmental Bureau for Informatics (IBI) has been active as an institutional organisation in the field of promoting the development of national strategies and policies. In cooperation with UNESCO, IBI organised a world conference in 1978 on this subject. The Department of Cooperation of IBI provides for its member countries' assistance and cooperative missions for policy planning.

The vision of IBI is that informatics technology plays a key role in the promotion of self-reliance and endogenous development and must therefore be subject to national policies. Information is perceived as a natural resource to be utilised, and informatics is concerned with the design and implementation of appropriate systems to utilise it. At the national level, informatics is therefore the study of the nervous system of the nation. It is therefore concerned with the basis for the generation of a social intelligence[8/] and effective decision making in any sphere: hence the need for a national policy.

The national policy of any country is individual to that country and depends on many factors including its stage of development. The issues that would form its substance could come under any of the headings that were listed above as the headings of international action, but the following would necessarily form the substance of any policy:

- awareness, education and training;
- identification of application priorities;
- acquisition of hardware and software;
- informatic infrastructural arrangements, including maintenance;
- communications;
- research and development;
- informatic industry developments.

Within such a broad national policy that covers economic, social, cultural and political aspects, industrialisation provides a special focus for the developing countries. An industrially oriented policy[9/] would, above all, be concerned to identify applications that would increase productivity and create employment.

Further studies are needed at the international level, based on an appropriate typology of developing countries, to elaborate national policies and international action is required to promote the adoption of appropriate policies in individual countries together with the establishment of the appropriate national bodies to be responsible for informatic developments.

7.3 *Awareness, Education and Training*

A major constraint to the development of informatics is the world-wide shortage of skilled manpower. Set against a 30% annual growth in end-user investment in hardware, this constitutes a serious failure of the education sector to come to terms with informatics.

In the first instance much more resources need to be devoted at the international level to increasing the level of awareness of informatics in national governments through carefully planned programmes of action, followed up by assistance to government departments in support programmes to alert managements to the industrial scope and potential of informatics and to assist in re-training staff.

As an integral part of a national informatics strategy education and training needs have to be established on the basis of manpower projections and the range of education and training provided that is appropriate to the specific needs of the country and to its level of development. An educational and training strategy of this scope can be achieved in developing countries only through international cooperation.

Education and training in informatics is within the mandate of UNESCO and is being given much attention by that body. Several recommendations of the first SPIN Conference underlined the importance of education in informatics and stressed that UNESCO should strengthen its programme to enhance informatics education at different levels, including post-university, university and pre-university, as well as public awareness education. In the 1981/83 triennium increased support is being given to post-graduate training courses and the establishment of centres of excellence in many different countries. Regional networks are being established to encourage lateral transfer of infotechnology through exchange of personnel and training. A special study will be undertaken to compile information on informatics information centres, educational and training establishments and courses offered, research and

experimental development institutions, research opportunities and fellowships. A pilot project to establish microcomputer laboratories in developing countries is also foreseen. This will include purchase of equipment, transportation, installation and training of staff. Support will be given to institutions in developing countries, especially teaching and research institutions, for the establishment of minicomputer centres, and advisory services will be provided[10/].

It will be essential for UNIDO to cooperate with UNESCO, IBI, ILO, and other bodies in order that priority is given to training programmes that will lead most rapidly to informatic applications supporting increased productivity and employment in the short term and the development of endogenous capacities in the longer term.

In the development and implementation of long-term, co-ordinated training strategies the international bodies should evaluate the usefulness of a number of large, manufacturer-independent, national training authorities that now exist in the industrialised countries and are able and willing to offer well-tried training services and materials to developing countries[11/]. Efforts should also be directed towards the development of similar regional training centres in selected Third World countries to operate on a TCDC basis[12/].

7.4 *Information Infrastructures*

The processes of information flow that support productivity are certainly not yet well understood or modelled and it will be necessary for international agencies to be involved in global

studies in order to identify the specific information related factors affecting industrial growth and the priority areas for the development of information infrastructures. The scale of the undertaking is enormous and only a highly selective, cost-effective approach will be feasible. For economic, operational and cultural reasons, the wholesale informatisation of a society as a means of providing a general infrastructure for industrialisation is not feasible in the shorter term.

Motivating such studies would be the concept of information handling capabilities as the nervous system of a society and of information as the ignition key to innovation and self-sustaining development, drawing the inventiveness and adaptiveness of local artisans, small entrepreneurs, etc. into a national development effort[13/].

The global studies, referred to above, carried out at the international level should result in the development of detailed models of suitable information services and systems of national information networks to meet the needs of a variety of end users[14/]. These include R & D personnel, technologists, engineers, industrial managers, economists, planners, investors, financiers, entrepreneurs, market analysts, sales personnel, industrial consultants, government decision makers. The type of information needed is also diverse: socio-economic data and statistics, financial, equipment available, management practices, patents, legislation, etc., etc. It has to be continuously updated and obtained from a variety of sources, at national, regional, global level. It is transmitted to end users in many forms ranging from oral communication to computer printouts.

It must be emphasized that this programme is much broader than the development of conventional documentation and abstracting services and STI networks.

UNIDO plays a unique role among the international agencies in the promotion of information infrastructures. The Industrial and Technological Information Bank (INTIB) was established within UNIDO under the Lima Declaration and Plan of Action on Industrial Development and Cooperation, Lima, Peru 1975, with a mission "to make available a greater flow to the developing countries of information permitting the proper selection of advanced technologies"[15/]. The functions of INTIB include the provision of assistance in the technology selection process and also the provision of assistance in the setting up of matching industrial information structures in individual countries[16/].

Industry Related Services Sector

It has been pointed out in Chapter 4 that the development of the information intensive sections of the services sector could be one of the most fundamental ways in which industrial growth could be stimulated. The modalities of such a development should be studied by UNIDO in cooperation with IBI.

Social Intelligence

As pointed out in Chapter 4, the most basic informatic problem is to imbue information with value in the eyes of the problem-solvers. The motivation will then be created to develop the appropriate

information networks as a basis for the generation of a social intelligence and effective decision making at every level.

Again the modalities for intervention in this area require study at the international level. The long-term solution involves the remodelling of the educational system[17]. The short-term strategy consists in 1) identifying the "gate-keepers"[18], 2) specifying the information services and systems most appropriate to their needs, and 3) devising crash training to create information-conscious cadres of problem-solvers[19].

7.5 *Communications Infrastructures*

Resolution A/Res/36/40 on World Communications Year 1983 adopted by the General Assembly of the United Nations on 19 November 1981 recognized 'the fundamental importance of communications infrastructures as an essential element in the economic and social development of all countries'.

In most developing countries inadequate communications infrastructures is one of the biggest obstacles to economic and social progress. The imbalance in communications are striking: 75 per cent of installed telephones are in eight countries and only 7 per cent altogether in countries classed as developing. Many rural areas lack electrical communications of any kind. Good communications increase social efficiency, that is to say improve response times for administrative and decision-making procedures. When travelling is systematically used instead of the telephone, efficiency is lost; when no-one knows

how long it will take to bring a procedure to a conclusion, efficiency is non-existent. Improved telecommunications both within and between developing countries will be essential for collective self-reliance and economic integration and a pre-requisite to industrialisation.

Studies in selected developing countries show that, for various sectoral interests, the indirect benefits of telecommunications are some tens of times more than the cash return. For example, the ITU investigated the impact of telecommunications on the performance of a number of business enterprises in Kenya. The enhanced economic performance resulting from better telecommunications was evaluated at 110 times higher than the total cost of providing the improved service. The evidence indicated that the benefits were greater in the remote areas far from urban centres.

The planning of communications developments must have regard to the rapidly changing telecommunications technology and also the changing costs. These changes increase the number of options available for countries with different basic characteristics such as geographical features, size, population density, etc., and also in different stages of development. Thanks also to the new satellite communications technology direct communication south-south has become possible. These options require to be investigated and, in parallel, studies undertaken of the existing examples of recently developed national communications systems.

International actions will be required to facilitate the preparation of national and regional programmes and to assist countries to undertake in-depth review and analysis of their policies on

communications.

Recent technological developments, e.g. in the use of digital telephone exchanges, satellite transmission, fibre optic cables, should be reviewed. A categorisation of developing countries, based on characteristics that would have a bearing on communications infrastructure, could be developed so that countries can be grouped together as communications problems. As a pilot project field surveys could be carried out in one or two countries in each of a number of country groups selected so as to be markedly different in their basic characteristics. In the selected countries, the national communications needs could be studied, with special reference to the demands in different sectors of industry and the growth projections of demand. Where appropriate, potentialities for the development of an indigenous telecommunications equipment industry could be investigated. For each country studied, a range of communications systems options could be developed, covering technical, economic, operational and financial feasibilities.

The next stage would be to equip the countries concerned with the capabilities to proceed with the development of plans for communications systems. As a first step and based on the communications scenarios developed to match the circumstances and requirements of different countries, appropriate training programmes in communications would be developed for personnel selected from country groups.

The training programmes would accordingly be individually tailored to the needs of each country group, being designed to match the technological information requirements related to the communications

systems options developed for that country group.

The output of such a pilot project carried out at the international level would be a technical report together with an integrated package of technical and cost data and a methodology, on the basis of which a range of options for a national communications systems appropriate to the needs of any individual country, possessing a specific set of conditions and requirements, could be specified in broad outline. The options developed would span the range from very low-cost systems, based, e.g. on a combination of subscriber radio point-to-multipoint microwave system and buried cable, to the highest technology based on satellite transmission.

Various very different kinds of models are available to be studied of existing recently developed national communications systems. This should be done within the framework of an integrated international development strategy. Developments in telecommunications in the Latin American Countries are reported by Galli[20/]. Hahn[21/] describes an inexpensive communications system, economic for a low-density population, based on a combination of subscriber radio and cable. Ireland is an example of a newly industrialising country, not burdened with old industry and traditional infrastructure, that has decided to invest £800 million in an integrated telecommunications system based on digital switching and transmission to integrate voice, data, text and pictures for transmission through the system[22/].

These and other such models should be studied within the framework

of an integrated international development strategy. ITU, with the collaboration of UNDP, has directed a major part of its development cooperation towards the interconnection of national networks of developing countries and their integration into a global telecommunication system and has promoted and is supporting many regional projects for bringing the developing countries together[23/]. Examples of these projects are the Pan-African Telecommunication Network (PANAFTEL)[24/], Inter-American Telecommunications Commission (CITEL), Asian Telecommunications Network (in collaboration with ESCAP), Arab Telecommunications Union (ARABSAT). The UNDP is also involved as a partner in a TCDC project to establish the Development Information Network (DIN). This project[25/] will be linking south-south, 60 developing countries at the first stage with the existing inter-regional network via satellite, as well as linking other developing countries to sub-regional redistribution centres terrestrially, and it is intended that the news agencies be the primary users.

UNIDO can, in cooperation with ITU, be involved in assisting individual countries to plan appropriate communications infrastructures with an emphasis on their impact on inudstrialisation, based on global studies to identify optimal choices of models and techniques.

7.6 *The Informatics Industry*

The considerations that would lead a developing country to adopt an indigenous informatics industry policy have been set out in Chapter 5. The elimination of dependency, including dependency in defence matters, may often override considerations of

comparative advantage. The benefits of interaction with applications, servicing and maintenance are also often important[26/].

The international agencies, more particularly UNIDO and IBI, can play an essential role in promoting the creation of appropriate national policies and strategies and establishing cooperation among developing countries. In the early stages this could focus on sharing experience and expertise in building up the institutional structures, capabilities and techniques[27/].

7.7 *New Products and Processes*

There are many problem areas of importance to developing countries where the industrialised countries do not have readily available knowledge or experience. Innumerable new products and processes are waiting to be discovered, e.g. in agricultural applications or in the form of cheap, rugged, portable, medical, electronic equipment for use in static or mobile rural health care delivery systems.

The development of new products and processes will require international action and cooperation and sharing of experiences among developing countries[28/].

7.8 *Applications*

It was pointed out in Chapter 4 that there is no reason to expect that the normal informatics applications in the industrialised countries would have much relevance to the problems of the

developing countries. These problems have to be looked at afresh in the light of the revolutionary advances in informatic technologies which create new possibilities for applications in all sectors of the economy. This again requires the cooperation of the international agencies.

Governmental Information Systems

No country has as yet fully solved the vast information handling problems involved in analysing and synthesising the vital national accounting, statistical and demographic data required for sound management of the nation-state and for national planning covering the development of regions and resources, land, water, forest, crops, livestock and the efficient employment of people. The appropriate information systems again will differ for developing countries in different stages of development and with differing characteristics and a series of comparative studies at the international level are required to identify suitable models.

There exist many governmental information systems in operation, both in developing and developed countries, so that the opportunity to study the best practice and to transfer appropriately modified models to new situations is there.

Governmental applications also represent an area ideally suited to stimulate the indigenous development of software. Software packages specifically tailored to national planning needs in developing countries have enormous potentialities and provide an opportunity for international agencies to encourage the setting up and execution of a great many projects similar to a number currently in progress, involving international cooperation, on the

design of software for national management of electric power and railway freight, for meteorological early warning systems, communications and language systems[29].

Decision Support Systems

In developing countries social intelligence capabilities to assess and evaluate raw information will be absolutely crucial to building up self-reliance and industrialisation. The most pressing needs are perhaps those for market intelligence and keeping track of new technologies and current thinking on technological forecasting[30]. This requires the development of management information systems (MIS) oriented towards long-term planning. As discussed in Chapter 2, management of an organisation is at three functional levels: the operational, tactical and strategic. The first level refers to the routine day-to-day operations, the second to the control and evaluation of these operations, and the third to long-term planning.

The development of MIS in the Third World need not necessarily go through the same evolutionary stages that were experienced in the industrialised countries[31]. The reason for this is that changes in the technology have provided greatly increased flexibilities and enhanced the capabilities of potential MIS, resulting in the possibility of developing all three levels at the same time.

Such development, nevertheless, is crucially dependent on effectively getting around the lack of the learning experience gained in proceeding evolutionarily through the operational, tactical and strategic level systems. This implies a greatly

expanded programme of education and training, involving universities, technological institutions, and the development of R & D institutes, information centres, industrial extension services, industrial consultancy services.

Bearing in mind that in developing countries there are difficulties in implementing even the simplest applications[32/], international agencies must work, to strengthen the managerial skills required, through industrial training centres, industrial extension services and consultancy firms, both nationally and regionally.

Small Scale Industrial Enterprises

International agencies should give priority to the promotion of informatic applications in small scale industrial enterprises which, as pointed out in Chapter 4, might typically account for fifty per cent of total industrial production. More specifically, efforts should be directed to encourage the growth of the industry related services sector to serve the small scale enterprises as a channel of appropriate informatics technology transfer[33/].

7.9 *The Role of UNIDO*

The key role for UNIDO initially is to promote national informatic strategies and policies with a focus on industrialisation. In cooperation with the other international bodies, a fully integrated programme should be developed with the objective of sensitising decision-makers to the whole range of issues involved. Within its mandate for industrial development, UNIDO is in a position to play a key role in planning and initiating the series of actions that are required.

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32. See Dublin Conference, page 431.

33. Narasimhan, R., Dublin Conference.

8. A CHECKLIST FOR NATIONAL SELF-RELIANCE IN INFORMATICS

8.1 *Introduction*

The formulation of an operational strategy for informatics development for a particular country is individual to that country and depends upon conditions, requirements, priorities and stage of development. The specific set of actions suggested in the checklist below is therefore illustrative only.

8.2 *Checklist*

1. A high level committee to be established at the level of the Office of the President or the Prime Minister. This committee would promote the need for awareness of informatics as a major concept and it would develop the concept of social intelligence generally, including associated infrastructures.

2. Consultations to take place with international bodies on development of policy. In this connection access to other country models can be obtained through international agencies.

3. Study groups to be set up to consider topics such as manpower training, industrial policy, etc.

4. A policy report to be prepared. This would set priorities for policy implementation and provide terms of reference for national bodies. It would also set indigenous informatics industry developments within national industrial policy.

5. Appropriate institutional arrangements to be made to set up national body(ies), e.g. a National Informatics Authority (NIA), to plan and regulate developments.

6. NIA to plan and implement national awareness campaigns of the value of information. The need for awareness of the value of information must be emphasised.

7. Appropriate government department to carry out national surveys of resources in equipment, manpower, and administrative, managerial and entrepreneurial skills.

8. NIA to investigate financial resources, nationally and internationally, and availability of funding sources for special projects (e.g. UNDP, UNIDF, IBI, UNESCO, regional and national development banks, etc.)

9. NIA to plan the industrial and technological infrastructures. This would cover industrial extension services, information centres, technology transfer centres, national information network and ensuring that existing bodies are brought fully into the overall plan, that new bodies are created where necessary and that appropriate links with UNIDO and other international information clearing houses, and other national and regional centres, are forged.

10. NIA to promote <u>relevant</u> applied R & D activities in third level colleges and universities and, if necessary, special centres, covering administrative sciences, management information and decision support systems, information science,

studies of the information needs of industry including, in particular, those of small scale industrial enterprises, microelectronics hardware and software technology, studies of innovative microelectronic applications in priority areas.

11. NIA to promote, in cooperation with the appropriate national bodies and if necessary by setting up new bodies, an integrated national plan for education and training in all aspects of informatics and documentation as well as related administrative and management functions.

12. NIA, in cooperation with the appropriate government departments, to plan appropriate measures to stimulate the development of the industry related services sector with particular reference to engineering and industrial consultancy in regard to developing their technology transfer functions and expertise in implementing information systems in industry.

13. NIA to ensure that special legislation for the regulation of the inflow of informatics technology, licensing arrangements, etc., come within the general governmental framework for regulating and promoting the transfer of technology in accordance with a proper policy implemented by a national technology transfer regulatory agency [1].

14. NIA, in cooperation with appropriate government department, to plan a national communications system, integrating it into planning at regional and global levels, in consultation with ITU and other relevant bodies.

15. NIA, in cooperation with the appropriate government departments and other national bodies concerned with industry, to coordinate the development of a comprehensive industrial strategy for informatics hardware assembly and manufacture, software production, maintenance and support services, within the framework of the national development plan, integrating the strategy at regional level as appropriate.

16. With the dual objective of increasing efficiency and of using government purchasing power as a substantial stimulus to developments in the informatics industry, NIA to promote a strategy for the development of information systems and data bases in government departments and public utilities, to be implemented through the further development of existing bodies or the creation of new bodies at national level as appropriate.

17. NIA to promote the development of sectoral plans for applications in e.g. agriculture, transport, energy, etc. These plans to be coordinated with overall plan.

18. NIA generally to promote informatic applications in the private sector through the information infrastructures set up for that purpose and through developments in the services sector.

8.3 *Comments on the Checklist*

The informatics policy that is developed will be conditioned by a number of factors such as the degree of state intervention, the

country's industrialisation policy, e.g. import substitution or export-led, and other basic country characteristics. The following issues would necessarily form the substance of any policy:

- institutional arrangements;
- awareness, education and training;
- governmental support, promotional measures and policy instruments;
- priority applications;
- hardware and software acquisition;
- informatics industry developments.

The two greatest obstacles to implementation in most developing countries will be lack of awareness of the value of information and lack of management skills and experience. Neither of these obstacles will be easily overcome, and indeed will only be overcome by integrated and sustained action at national, regional and global levels.

It should be borne in mind that at each stage in the national development of informatics, from the initial creation of policy to the actual implementation of operational systems, a nation can obtain a great deal of information, guidance and sharing of experience through the international agencies. General referral points would be the Industrial Information Section of UNIDO and the Department of Cooperation of IBI.

It should also be borne in mind, in studying the checklist, that Informatics is not "just another mystification" [2/] or "just

another technology" [3] and that an integrated development must take place in harmony with clearly defined development goals and using existing governmental agencies and policy instruments and the capacities of existing institutional infrastructures, creating new entities only where necessary.

The development of informatics must be set within the broader framework of national policy for economic and industrial development. The need for special and careful consideration of informatics arises because it cuts across and interacts with practically all other strategic areas and sectors of a nation. An absolute prerequisite for the success of any national strategy for informatics development will be the creation of a lively awareness at the highest levels of the value of information and of the concept of informatics as a major concept in development [4]. If self-reliance is the first major concept in the formulation of development goals, then informatics, meaning all the problems and the infrastructures involved in the promotion of social efficiency and social intelligence [5], is in turn a prerequisite to self-reliance.

NOTES AND REFERENCES FOR CHAPTER 8

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2. See Dublin Conference, Section 1.

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